MODALITY RELATED PERFORMANCES IN EDUCATIONALLY HANDICAPPED CHILDREN: AN OPERANT ANALYSIS

By

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To the late Henry Koorland,

a very gentle man

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MODALITY RELATED PERFORMANCES IN EDUCATIONALLY
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There has been a great deal of interest in modality preference as a learner characteristic and its relation to learner performance. To the extent that it is difficult to determine consistent auditory or visual modality preferences, some investigators, nevertheless, claim that aptitude treatment interactions between modality preference and presentation mode indicate preferences which are stable across tasks, and that these preferences control the subjects' performances on a short term memory task.

If a positive reinforcer proves to control performances allegedly dependent on modality preferences, then there will be a greater understanding of the variables that contribute to the consistency of modality preference, and subsequently an explanation of the reasons for a subject's performance could be offered at a functional level, rather than at a nominal level. For these reasons the study was designed to use a set of tasks previously

found to be successful in demonstrating an aptitude treatment interrelation between modality preference and presentation mode. The study employed operant techniques to further clarify the variables that might control alleged modality dependent performances with educationally handicapped children.

Subjects were classified as to modality preference by their performance on a bisensory digit span task. This task consisted of simultaneous presentation of four-digit spans in five criterion trials. The number of visual responses were subtracted from the number of auditory responses and the magnitude and direction of the differences were used to identify the subjects' preference.

Subjects with a preference then performed on a bisensory missing units short term memory task. This task consisted of simultaneous auditory and visual presentations of two different sets of three words. Following the bisensory presentation the subject was shown two of the three words from each set and asked to recall the missing word. To meet the criteria for an aptitude treatment interrelation, the subject had to recall, in any ten trials, six missing words from the same presentation mode as their preference classification. After screening 18 elementary aged children, one male with an auditory preference and treatment interrelation and one female with a visual preference and treatment interrelation were identified for the study.

A single subject design employing a multielement baseline was used to evaluate the effects of contingencies of reinforcement on the subjects' bisensory missing units task performance, allegedly under the control of modality preference. Data were evaluated by

visual inspection of the subjects' cumulative response records and distributions of the subjects' response latencies.

Contingencies of reinforcement were found to control both subjects' missing units task performances. Performances in non-preferred modalities could be made to approach or exceed performances in preferred modalities by the systematic use of contingencies of positive reinforcement.

These results imply that the source of control for modality related performances and subsequently the source of stability or consistency of a subject's alleged preference controlled performances may depend on controllable variables in the immediate environment, such as reinforcement. One implication of these findings is that a learner may perform better in a supposedly non-preferred learning modality than expected, if the consequences for that performance are reinforcing, and if the consequences are arranged systematically.

CHAPTER I

INTRODUCTION

Operant conditioning and its associated technologies have demonstrated, in various investigations, control over measures of abilities or traits that have been considered relatively stable or immutable characteristics of the person, e.g., IQ scores (Clingman & Fowler, 1976), and sensory thresholds (Goldiamond, 1962). Operant technology provides a viable set of methods and procedures for demonstrating the dynamic nature of learning and associated performances (Edinger, 1969). More specifically, modality preference, a type of individual characteristic (DiVesta, 1975; Ingersoll & DiVesta, 1972), may be under the control of contingencies of reinforcement, rather than under the control of a pervasive trait, aptitude or innate characteristic. Therefore, the purpose of this research was to investigate the stability or consistency across tasks of modality preferences or aptitudes by using operant procedures to demonstrate the function of dynamic environmental variables in the control of performances alleged to be dependent on these preferences or aptitudes.

Modality preferences have been considered a type of aptitude that would greatly enhance the study of presentation modalities and their effects on learning and recall (Ingersoll & DiVesta, 1972; Sabatino & Dorfman, 1974). Lilly and Kelleher (1973) used

the terms modality strength, modality preference, and learning style interchangeably in their investigation of modality preference and learning. In all subsequent sections, because of the frequent interchangeable use of the above terms in the modality literature, aptitudes, modality strengths, and preferred learning modality are used interchangeably when referring to modality preference.

Special educators have been proposing that learning disabled children have discrepancies in visual and auditory processes that result in poor achievement (Waugh, 1973). Attempts to determine accurately the visual or auditory modality preferences of handicapped children have not often met with success (Mann, Proger, & Cross, 1973; Sabatino, Ysseldyke, & Woolston, 1972). Consequently, matching these children to appropriate instructional programs also remains difficult. Some investigators have suggested that inadequate instrumentation and measurement procedures may contribute to the difficulty in identifying a learner's modality preference (Estes & Stewart, 1975; Foster, Reese, Schmidt, & Ohrtman, 1976; Mann, Proger, & Cross, 1973; Sabatino, Ysseldyke, & Woolston, 1972; Wolpert, 1971). Because the primary means for identifying modality preference involves the use of norm measures such as the ITPA (Kirk, McCarthy, & Kirk, 1961) and other psychometric modality tasks of many forms, e.g., Wepman, Frostig, Ladd, Mills, and Valett tests (Meeham, 1974), other types of tasks, may warrant investigation. Smith (1971) suggests the use of techniques which are more specifically auditory or visual in nature, i.e., eliminating motor responses or instructions using other modalities.

Ingersoll and DiVesta (1972) used a laboratory type task to identify visual and auditory attenders among a group of college age students. The task was a bisensory digit span type, consisting of simultaneous presentation of different auditory and visual four-digit spans. After presentation of the stimuli, the subject was to recall as many digits as possible. The modality in which the subject recalled the most digits correctly was used to classify each subject's preference as either auditory or visual. This task was followed by a type of short term memory exercise consisting of a bisensory missing units task that required the subject to respond with missing words from two independent sets of words. Each independent set was presented simultaneously in a separate modality. The results indicated an aptitude (modality preference) by treatment (presentation mode) interaction implying that the identified modality preferences were stable across these tasks (Ingersoll & DiVesta, 1972). This series of tasks was replicated with a number of educationally handicapped children and indicated what appeared to be stable modality preferences for these learners, while avoiding difficulties found in the use of psychometric modality tasks.

Statement of the Problem

This study was designed to determine if modality related performances in elementary aged educationally handicapped children were subject to control by contingencies of reinforcement rather than control by a pervasive trait, aptitude, or innate characteristic.

Consequently, existence of a functional relationship between contingencies of reinforcement and the type of response, allegedly controlled by modality preference, on bisensory short term memory trials was investigated.

Questions Under Investigation

This study was designed to answer the following questions regarding the influence of contingencies of reinforcement on performances allegedly controlled by modality preference in elementary school aged educationally handicapped children.

1. Is there a functional relationship between contingencies of reinforcement and short term memory performance allegedly under control of a visual modality preference?

2. Is there a functional relationship between contingencies of reinforcement and short term memory performance allegedly under control of an auditory modality preference?

Rationale

At the core of special education is the search for strategies leading to effective individualization. The determination of a student's preferred learning modality in order to insure that appropriate treatments are provided, is one way in which individualization is carried out. Because the modality concept has been promoted as well as used as an explanation for achievement or lack thereof (Wepman, 1968), it has resulted in a proliferation

of assessment devices and even modality specific commercial teaching materials. Unfortunately the emphasis on the modality concept has resulted not only in commercialism, but also in wide acceptance of the general strategy of determining modality preference and subsequent selection of materials by sensory modality. Many involved in the modality enterprise have overlooked the complexity of the learning processes involved (Landers, 1976) and the inconclusive nature of modality research. The rationale for this study is derived from two substantive areas related to modality research. They consist of the variables affecting performances allegedly under the control of modality preference, and the determination of stable modal preferences.

Variables Affecting Performances

When determining the variables that affect modality dependent performances, most often demographic characteristics such as age, IQ, socioeconomic status (Blanton, 1971; Williams, Williams, & Blumberg, 1973), developmental processes (Wepman, 1971), and sex (Dwyer, 1971; May & Hutt, 1974) are investigated.

Infrequently, but nevertheless important, motivational characteristics of the immediate learning environment have been suggested as factors that may affect the student's performance in learning modality studies (Dunn & Dunn, 1974; Williams, Williams, & Blumberg, 1973). In contrast, Wepman (1971), in reference to modality preference, states, "the choice appears not to be conditioned by the environment but seems more likely to be an innate characteristic" (p. 6). In order to clarify the relationship

of variables in the immediate environment to modality dependent performance, the use of operant technology would seem warranted.

Operant conditioning procedures have been shown to modify behaviors thought to be controlled by pervasive organismic variables, relatively resistant to intervention. These variables are, for example, autonomic responses that control human gastric acid secretion (Whitehead, Renault, & Goldiamond, 1975), neurological impairments that control written letter reversals (Smith & Lovitt, 1973) and learning disabilities and general mental abilities that control aptitude and intelligence test scores (Clingman & Fowler, 1976; Kubany & Sloggett, 1971). These studies demonstrate the influence of environmental variables and subsequent changes in behaviors thought to represent pervasive characteristics. There has been no systematic investigation, using operant technology, of performances allegedly dependent on modality preferences.

Determination of Stable Modality Preference

There appears to be wide agreement that the detection of modality preference is impeded by the lack of reliable and valid instrumentation (Ysseldyke, 1973). In order to move toward tasks that effectively divide attention between visual and auditory channels and thus indicate the primary modality of attending, the bisensory simultaneous stimulation paradigm has been employed (Dornbush, 1968). Ingersoll and DiVesta (1972) mention that Broadbent, while employing this type of recall task noted that subjects had their own consistent preference for giving information

received in the auditory or visual channel first. For this reason, Ingersoll and DiVesta used the bisensory digit span task to identify visual and auditory preferences of their subjects. After identifying the preferences, the subjects were given a second task which was a bisensory modification of the missing unit paradigm. This procedure consisted of presenting five words to the subject, then repeating four of the five words and asking the subject to write on a record sheet the missing word or unit. The bisensory modification involves the simultaneous auditory and visual presentation of different sets of words. The authors found that those subjects identified as having auditory preferences recalled more auditory materials and those identified as having visual preferences recalled more visual materials. DiVesta (1975) notes that to identify the missing word from the originally presented sets is an impossible task unless one assumes that people develop consistent, selective, and automatic information processing strategies.

Consequently, these laboratory-type tasks might be more directly responsive to auditory or visual preferences and thus avoid some of the problems encountered with other methods of assessing modality preference, e.g., psychometric instruments.

Additionally, Ingersoll and DiVesta (1972) state that replication with different subjects is necessary. They point out that the use of elementary school children, a more heterogeneous group than the original population of college students, would allow selection of more extreme scores relative to modality preference.

Extreme scores should produce clear response patterns on the bisensory missing units task. If the results can be replicated, then the authors believe that the generality of the construct of modality preference can be extended.

Elementary age educationally handicapped children are often the focus of individualized learning treatments and modality related materials. Their use as subjects seemed warranted, because of age and relevance to the modality enterprise. This set of tasks reliably indicated whether modality preferences existed in the population under study and also provided results similar to the aptitude treatment interaction (ATI) between modality preference (aptitude) and presentation mode (treatment) obtained by Ingersoll and DiVesta (1972). Results similar to the original ATI implied that these modality preferences were stable across tasks. Once results similar to Ingersoll and DiVesta's (1972) findings were obtained, the effect of contingencies of reinforcement on task performances allegedly under the control of modality preference were investigated.

Definition of Terms

1. Modality Preference - Preferences are "monitoring and filtering systems which control the flow of information within a processing system" (Ingersoll & DiVesta, 1972, p. 391). This is determined by the magnitude and direction of correct recall on a bisensory digit span task. After five sets of trials, the number of visual responses are subtracted from the number of

auditory responses. The previously set criteria of ± 3 (Ingersoll & DiVesta, 1972) was used to classify subjects. Those who did not meet the established criteria were dismissed from the study.

2. Bisensory Digit-Span Task - Simultaneous presentation of different auditory and visual four-digit spans. The subject is asked to recall the set in whatever order he prefers.

3. Bisensory Missing Units Task - Simultaneous presentation of different three word sets. One set is presented auditorily and the other visually. The words are drawn from A Teacher's Word Book of Twenty Thousand Words (Thorndike, 1931). The subject responds with the missing word, when two words from each set are presented visually following the original presentation.

4. Aptitude Treatment Interaction (ATI) - An ATI is a significant interaction between personological variables and alternative treatments. This study does not use statistical tests of the subjects' data to operationally define an ATI. Rather, an ATI is said to exist for those subjects who demonstrate a modality preference and also remember 60% of the words presented on a sensory channel corresponding to their indicated modality preference.

5. Educationally Handicapped Child - Children who are classified as non-retarded and who are at least one year below age appropriate grade placement in one or more academic areas. The child has no physiologically based sensory handicaps.

Delimitations of the Study

The use of the bisensory digit-span tasks have not been validated as an indicator of modality preference with any task other than the missing units task. The generality of any modality classification derived from this procedure to tasks of varying content and complexity levels is not yet established. As such, a modality preference determined with the laboratory tasks may not be generalized beyond short term memory functions.

The use of educationally handicapped students as defined earlier may impose restrictions on the generality of the findings. Any operational definition for educationally handicapped students is bound by the limits of the instruments used to determine subject characteristics.

Summary

The determination of modality preferences that are stable across tasks in exceptional students has met with limited success. The use of psychometric instrumentation has been cited as a factor contributing to these results. Laboratory tasks, however, were used by Ingersoll and DiVesta (1972) to demonstrate stable modality preferences in adults. Using these similar tasks evidence of stable modality preferences were sought with educationally handicapped children and, when found, further investigated by the use of operant technology. Operant techniques

were used to investigate the responsiveness of alleged preference controlled behavior to environmental influence.

CHAPTER II

REVIEW OF RELATED LITERATURE

The following review is divided into three sections. In the first two sections salient studies related to modality preference and mode of presentation are reviewed. Within these sections, studies are further divided by type of experimental population. In the third section, operant technology and its value for modality research are discussed.

Modality Preference

A mode or modality is a sensory channel, such as visual, auditory, tactile or muscular movement, through which sensations are transmitted and received (Jones, 1972). General interest in the area began in the latter part of the nineteenth century. The purpose was to compare listening and reading as input channels for comprehension and analysis of various materials (Jones, 1972).

Ysseldyke (1973) points out the influence of Cronbach and Reynolds in urging psychologists and special educators to research how individual's aptitudes could be joined with instructional systems or treatments in order to identify and use aptitude-treatment-interactions.

Bracht (1970) states the goal of aptitude treatment interaction research is identification of disordinal interactions between personological variables (IQ, specific abilities, personality variables,

and others). In light of the above, an interest developed among special educators in determining the most efficient channels of learning. Evaluation instruments and complimentary instructional programs have been devised, based on the premise that the identification of preferred modalities in instruction would lead to more effective learning (Waugh, 1973). Additionally, it was felt that weak modalities could be identified and instructional activities could be designed to remediate those weak modalities or processes.

There remains much emphasis on the determination of modality strength for purposes of matching specific instructional procedure to a given learner's aptitude (Dunn & Dunn, 1974; Sabatino & Dorfman, 1974). Despite often contradictory results, some investigators feel that it is premature to discard research on modality preference (Foster, Reese, Schmidt, & Ohrtman, 1976).

Most often problems in modality research are related to accurate assessment of modality preference (Jones, 1971; Jones, 1972; Mann et al., 1973; Smith, 1971) and the use of treatments that are uniquely auditory or visual in nature (Foster, Reese, Schmidt, & Ohrtman, 1976; Lilly & Kelleher, 1973; Smith, 1971). The following review compares and contrasts successful and unsuccessful modality treatment interaction studies with handicapped and non-handicapped populations.

Studies of Significant Interaction

The published studies indicating modality preference and treatment interaction are relatively few. Indeed, the number of studies indicating any aptitude by treatment interaction is small. Bracht

(1970) reviewed 90 aptitude-treatment-interaction studies and only found five that met the conditions for a disordinal interaction. It must be kept in mind that interaction can be of two types: with or without reaching significance. Bracht's requirements were of the former type and as such fairly rigorous. Researchers after 1970 have attempted to improve on methodological features.

Studies of non-handicapped. An investigation (Ingersoll & DiVesta, 1972) with a college age population obtained an interaction of modality preference and presentation mode for a short term memory task. The value of this work to the present discussion is the nature of the task. The subjects were engaged in a bisensory digit span task that required them to recall numbers presented simultaneously in an auditory and visual presentation. Those identified as auditory or visual attenders were then given a bisensory missing units task consisting of five words simultaneously presented in the auditory and visual mode. The subject was then presented four words from each modality and asked to recall the missing word. Modality preference and its interaction with the treatment were found. The authors state that the results indicate the stability of modality preferences across the two tasks. This procedure meets many of the criteria for tasks that have been found to produce accurate indications of modality preference, i.e., stability across tasks or interaction with mode of presentation, a task involving short term memory, and relative face validity of the task for a particular modality.

Kalin and McAvoy (1973) demonstrated that college age students provided valid data when asked to rank their modality preference. The

validity was apparent, because the data were used to provide accurate matches to instructional methods. Those students choosing visual presentation performed better in that mode than in the auditory mode and vice versa. Of course, this self disclosure of preference was obtained from a group keenly aware of study procedures and associated difficulties. Consequently, the utility of this approach, for children, would be limited.

Wepman and Morency (1975) obtained a successful modality-treatment interaction in normal first grade children. They used tests with high content validity in order to measure the perceptual parameters of interest. Some of the tasks involved auditory and visual presentation of discrimination tasks (requires same or different response) and memory tasks (repeat numbers in order and words in any order). A standardized reading achievement test was given after phonic and sight word approaches were used for treatments. An interaction between modality preference and presentation mode of treatment was obtained. Wepman and Morency (1975) noted that success was due to the use of auditory memory and sequential memory tasks that others have failed to use. Also, there were no motor components involved in the tasks and it is felt that motor components may have confounded previous attempts at modality preference indentification.

In the most recent and successful study, Foster, Reese, Schmidt, and Ohrtman (1976) used a small number of non-motoric tasks, related directly to reading, e.g., phoneme discrimination and word recognition. These tasks were used for modality classification. The subjects successfully were taught unknown words by the use of pictures and by the

use of phoneme-grapheme relationships. Parenthetically, the authors note that many children were screened in order to form the small experimental groups for this study. The effort required to identify such a small sample prompted the authors to point out that teaching through the preferred modality may be unimportant for the majority of children. Conversely, research on teaching through a preferred modality might be all the more important for the minority of learners classified as educationally handicapped.

Studies of handicapped. To date there is only one study using a population identified as handicapped that found modality preference to interact with a treatment. In 1973, Lilly and Kelleher attempted to correct some problems typically found in modality studies. They cited difficulty with dependent variable measurement and noted that tasks with at least face validity in relation to the reading process were necessary. In order to identify modality preference in subjects, they used a visual or auditory memory task for words. Points were assigned for words remembered and preference was determined by subtracting auditory scores from visual scores and using a certain number of points in one direction as criterion for a particular preference. The dependent measure involved reading or listening to a passage and recalling salient facts. Those subjects originally identified as preferring the auditory modality performed better on the audio passage and those identified as preferring the visual modality performed better on material read.

In order to perform this study, however, the students had to read at least at a 2.5 grade level. Consequently, the determination

of modality preference for younger students would present difficulties. Of value, though, is the demonstration of high face validity in tasks and more or less direct measures of performance, i.e., number of facts remembered as a dependent variable.

Studies of Nonsignificant Interaction

This category is the largest of modality preference studies. The dependent measures are primarily concerned with some aspect of reading. Jones (1971), in a review, points out that various researchers in studies employing psychometric tests such as the ITPA (Kirk, McCarthy, & Kirk, 1961) or combined batteries of tests (deHirsh, Jansky, & Langford, 1966) have difficulty supporting the theory that modal preference of an individual should be considered in teaching him to read. Jones concludes that it is difficult to isolate the auditory or visual modality, but recommends more experimentation to determine the relationship of modal preference to learning.

Studies of non-handicapped. Bruininks (1968) used the instrumentation approach typical of many unsuccessful investigations, i.e., psychometric instruments of a normative nature. Using a battery of 12 tests, he found that groups of auditory and visual learners did not profit from reading instructions based on perceptual strengths or weaknesses. Because the subjects, low socioeconomic status (SES) second and third graders, had been in school up to three years, the authors concluded that the students' reading habits from previous instruction might be more influential than perceptual characteristics in determining their performance. This is an atypical conclusion in

modality studies in that experience is noted as a possible factor affecting the results. The author also states that the tests used may not measure the most significant factors involved in reading instruction.

Cullinan, Ringler, and Smith (1969) using a relatively concise test, the New York Modality Test, composed of visual, auditory, and kinesthetic subtests, identified three groups of first grade urban learners corresponding to three modal preferences. The learners received visual, auditory, and kinesthetic word recognition training emphasizing configuration, specific sounds, and words formed by using pipe cleaners as letters fixed to a card. Using the Metropolitan Achievement Test as a dependent variable, they found no differences between the experimental groups. The authors conclude that the use of a standardized reading achievement test with inner city subjects, insufficient teaching time (7½ hours), and no coordination between the regular class activities and the various experimental treatments were possible problems. This study is one of the earliest to mention difficulty with using standardized tests as the dependent measure.

Smith (1971) in a study of low SES primary subjects found no relation between modality strength, classified using ITPA subtests, and visual treatments (use of the Initial Teaching Alphabet and Words in Color) or auditory treatments (reading with phonics). The Metropolitan Achievement Test served as a dependent measure. Smith concludes that if differences in children, relative to auditory and visual functioning exist, then the ITPA may be inappropriate for diagnosis. This finding is in agreement with earlier work (Bateman,

1968; Cripe, 1966). The dependent measure, however, was not mentioned as possible limitation for Smith's (1971) study.

Newcomer and Goodman (1975) used the ITPA as part of a battery of 18 tests. They found no interaction with an associative learning task or a meaningful learning task. Additionally, they found the visual condition of the treatment superior for the majority of the 4th grade normal subjects in the study. This result is in keeping with Bruininks (1968) earlier work.

Studies of handicapped. Waugh (1973) using the ITPA and an additional test attempted to correct for inadequacies of tasks used for dependent measures in earlier studies. Simplified recall along with word recognition tasks, similar to tasks used in actual instruction, were used. Waugh found that there was no relation of preference to treatment. In an ad hoc analysis it was noted that the auditory subjects did better on the auditory and visual recall task. Thus, the ITPA might serve to identify auditory perceptual functioning related to tasks at the recall level of complexity. For the reading task, however, no statements could be made for either the auditory or visual groups. Possibly reflecting the results of all modality preference research up to that point in time, Waugh (1973) states, "special educators at all levels must continue to ask an essential question - is this really a useful activity?" (p. 469). Waugh's population was handicapped only to the extent that they were enrolled in Title I reading. To charge special educators with such an essential question was probably premature in view of the heterogeneity to be found in most special

education populations. At best, Waugh's population, as a whole, would be considered borderline exceptional by most special educators.

Sabatino, Ysseldyke, and Woolston (1972) gave a battery of perceptual tests to mentally retarded subjects. The treatment involved unisensory perceptual training matched to the indicated strength of the subject. Gains were found on perceptual measures but were not specific to the kinds of training received. Group reading achievement tests were given as an additional dependent measure and no significant gains were detected. The authors conclude that present modality classification instruments have sizable error and may classify children in specific modality areas by chance.

Using 116 mentally retarded children as subjects, Sabatino and Dorfman (1974) arranged three groups consisting of auditory, visual, and non-preferred categories. They used a normative battery of tests; some derived from the ITPA. These groups were matched to a commercial visual reading curriculum (Sullivan Series) and an auditory reading program (Distar). Pre and posttest scores, obtained using an individual achievement test, produced no interaction. The authors conclude that possible lack of reliability in the instruments and use of measures that were not factorily simple may have contributed to the nonsignficant findings.

Tyler (1974) using a similar population and instrumentation received similar results. Parenthetically, the author mentions that all responses of the subjects in the present study were reinforced. This is the first statement about environmental contingencies

to be found in any of the modality preference-treatment studies to date.

In summary there are some statements that apply to most of these studies in modality preference:

1. Every test of modality preference employing the ITPA or selected subtests provided non-significant modality-treatment interactions.

2. The use of large comprehensive batteries to determine modality preference essentially did not prove to be more effective than the use of a smaller number of tests.

3. The use of normative or psychometric instrumentation appeared, in general, to lack the sensitivity to detect modality preferences or treatment gains.

4. Little or no information is provided about experimenter application of contingent reinforcement to the performance of subjects.

Unless there is an interaction between the preferred modality and the specialized treatment, it is very difficult to determine where the basic weakness in the study lies. It could be in the modality identification procedures, purity of the treatment, or the method of analysis. There is a possibility that, because of the present state of the art, few reliable generalities can be made about modality preference.

Presentation Mode

Many studies related to the learning modality area are concerned with presentation mode in particular. A unifying feature of many of the studies included in this area is the type of dependent measure used and the data analysis model. For the most part, tasks used for dependent measures are paired associate, short term memory, or other specific skills (Silverston & Deichmann, 1975). In every study, group research designs and confidence level statistics are used for analysis.

For these studies, researchers may employ handicapped subjects or handicapped and non-handicapped comparisons, but the majority employ elementary level low SES or normal populations. The studies are reviewed by population and various distinguishing features are mentioned.

Studies of Handicapped

In studies of learning disabled children, Estes and Huizinga (1974) and Estes and Stewart (1975), using paired associate tasks under visual and auditory presentation modes, noted visual tasks produced a greater number of correct responses than auditory. It is suggested (Estes & Stewart, 1975) that instructional materials for these subjects should be oriented to visual processing, yet in the same discussion the authors state, "in learning disabilities . . . heterogenity of psycholinguistic functioning and learning styles is the rule rather than the exception" (p. 5). This seems inconsistent with the determination that learning disabled children in their studies performed best under the visual presentation mode.

In a study of retarded adults, McConkey and Green (1975) investigated presentation method and its effect on free recall of categorically related items. They used auditory, visual sequential, and visual simultaneous presentation modes. Although primarily interested in the use of categorial strategies during recall, they noted that both groups receiving visual input recalled more items than the group receiving auditory presentation. This result is congruent with many of the other studies (Bruininks, 1968; Estes & Huizinga, 1974; Estes & Stewart, 1975; Newcomer & Goodman, 1975).

Studies of Non-Handicapped

Galfo (1970) in a study based on Broadbent's limited capacity processing model, which states that redundant presentation of program material will result in no increase in learning, obtained results at variance with the limited capacity theory. He found that simultaneous sight sound presentation with normal subjects proved superior to sight and sound separation. The task, however, involved academic material, and as such might involve level of familiarity factors or complexity exceeding that of tasks used in other studies in this area.

A study more typical of the mode of presentation and specific skills type under review was conducted by Filmer and Linder (1970). Using low SES subjects, they employed a short term memory task requiring recall of colors, digits, and pictures. The task was presented in the auditory, visual, and auditory-visual combined modes. The combined mode yielded the highest scores on each task; the auditory yielded the lowest. These results are in agreement

with Galfo's (1970) study. Of special importance, however, is that the researcher states that immediate feedback on correct and incorrect responses was given. This is the earliest and one of the few indications of the use of feedback or reinforcement. It must be kept in mind that the feedback was not a variable under investigation.

Reynolds, Bickley, Champion, and Deckle (1971) noted that very few of the studies employing word association tasks take mode of presentation of stimulus words into consideration. Consequently, they obtained results with low SES subjects that indicate responses to word association tasks are a function of stimulus modality. They also noted that as children get older the difference in type of response to oral and graphic presentation of words becomes less pronounced. Silverston and Deichmann (1975) noted age dependent relationships between modality skills and various reading indices. It would appear, then, that experience and other environmental variables may interact with performance on tasks related to various modalities.

In a study of encoding processes, in second grade children's short term memory, Corsale (1974) used mode of presentation as an independent variable. The subjects were required to recall categorically related words after a brief interference period. Although mode of presentation for this type of task plays a role in adults, it was not found to have an effect on the children's encoding. Although Corsale's procedures differed because of the use of an interference procedure, this result is interesting in relation to McConkey and Green's (1973) finding that mode of presentation for retarded adults differentially affected recall of categorically

related items. It might be of value to determine if there is any parallel performance for handicapped children as there is for both handicapped and non-handicapped adults. Mode of presentation occasionally appears to have generality across very different populations.

Williams, Williams, and Blumberg (1973) found that middle class subjects perform better with visual presentation in a paired associate task while lower class subjects learned better under an auditory condition. In relation to social class and performance on paired associate learning tasks, they state the following:

> because of related motivational differences it is difficult (unfortunately) to find a situation entirely free of these possible confounding factors. (p. 358)

It is interesting to note that some researchers of modality choose either to ignore motivational variables or to treat motivational variables as a nuisance rather than subject matter worthy of investigation in its own right.

Comparison of Handicapped and Non-Handicapped

Budoff and Quinlan (1964) compared auditory and visual presentation modes in normal and retarded readers. They used a meaningful paired associate learning task for second graders and found that the auditory presentation was superior in both groups. This finding does not hold true across other studies (Bruininks & Clark, 1972; Katz, 1967).

Katz (1967) employed a discrimination task presented in the auditory and visual mode at different levels of familiarity using

normal and retarded readers. Familiarity was defined as frequency of occurrence in the culture. The authors employed the Hebrew alphabet and associated letter names as the unfamiliar stimuli and the English alphabet and associated letter names as the familiar stimuli. Katz (1967) found that stimulus modality interacted with level of familiarity. He concluded that effects of stimulus modality are differentially related to the response required of the subject. The best performance was obtained with the visually familiar stimuli. These results raise the issue of stimulus meaning as a variable which will influence results. In many of the presentation mode studies this variable is not taken into consideration.

Bruininks and Clark (1972), using first grade disadvantaged educable mentally retarded children, disadvantaged non-retarded, and advantaged non-retarded, studied the efficacy of auditory, visual, and combined presentation modes. The results failed to show any difference on paired associate tasks between disadvantaged and non-disadvantaged of similar intellectual ability. Overall the total group responded best under the visual condition. The authors concluded that young retarded children exposed to auditory activities ought to have visual picture opportunities at the same time. To the extent that this study is typical of the others, it is also unusual because the authors point out that the subject was not informed of his correct or incorrect responses. This is opposite of the tactics that Filmer and Linder (1970) employed. Both studies used audio, visual and combined presentation modes, both studies employed low SES subjects and recall tasks, yet different results were obtained.

The differential use of feedback or reinforcement may have contributed to the difference in outcomes.

In summary, from the studies reviewed some conclusions may be offered.

1. Rarely is information concerning consequences of the subjects' responding made available.

2. The majority of the studies appear to demonstrate favorable results under visual presentation modes, but because of the prevalent group research strategies the performance of individuals are not reported.

3. Studies employing a non-complex task, i.e., short term memory, provided more consistent results than studies employing complex tasks, i.e., study of academic materials.

From these conclusions and conclusions of the Modality Preference section, the need for alternative research strategies, continued use of non-complex tasks, and attention to environmental variables becomes apparent. In the following section on Operant Technology alternative research strategies and environmental variables are considered.

Operant Technology

The growth and development of operant technology has been steady and has had impact on diverse areas of research (Kazdin, 1975). More specifically, the techniques of applied behavior analysis, which embrace many of the traditions of present laboratory practices, have been directed toward the needs of special educators, who, by definition, are charged with bringing unique procedures,

materials, and modifications of, or additions to school practice for the handicapped (Kirk, 1962).

Applied behavior analysis attempts to demonstrate quantitative characteristics of the behavior, the experimental manipulations, and the technologically exact description of the methods used to bring about change in behavior. Additionally, the change must be effective enough to have value and also possess generality within limits (Baer, Wolf, & Risley, 1968).

To the extent that science is a rigorous exercise in measurement, applied behavior analysis (ABA) requires certain standards of measurement and design. The use of intra-subject designs permitting replication (Sidman, 1960) is considered basic. Additionally, measurement requirements for the assessment of reliability of behaviors under observation are an integral part of ABA practice.

To appreciate that behavior of importance in applied settings is the focus of ABA, one only needs to consider the diversity of settings in which ABA techniques have taken place: day care centers, early education, Head Start, elementary schools, secondary education, college settings, special education, community settings, and clinics (Ulrich, Stachnik, & Mabry, 1974).

Operant conditioning has been applied not only in a wide range of settings, but also for the purpose of investigating a wide range of behaviors in those settings. Repeated demonstration of reinforcement as the controlling variable for certain classes of behavior have established the generality and usefulness of the reinforcement principle for those classes.

Recently, operant conditioning strategies have been applied to relatively traditional research areas (Clingman & Fowler, 1976; Goldiamond, 1962; Lovitt & Smith, 1973). Goldiamond (1962), in a discussion of perception, points out the importance of questioning the locus of response change in sensory threshold, hypnotic perception and related perceptual research. In relation to controlling variables, Goldiamond states, "where it is possible to choose between sensory and response loci, the evidence has supported a response locus" (p. 315).

Just as the application of new procedures to perceptual research (Goldiamond, 1962) may have evoked comments of doubt by those who had a vested interest in the area, i.e., psychophysics researchers and traditional psychologists, so has the initial application of operant procedures to newer areas.

Psychometric testing has in the recent past received some attention from individuals working with operant technology. Because of the standard procedures that must be adhered to (Cronback, 1970) in order to appropriately administer a psychometric instrument such as an intelligence test, any variation from that procedure is seen as a source of invalidity for the results. Commenting on the use of contingent reinforcement for correct answers on such instruments, Conner and Weiss (1974) state that all scores will shift upward and each subject's position in the distribution will remain the same. The problem with Conner and Weiss's conceptual analysis is that it was not based on experimental data; it was based, no doubt, on their measurement training and theoretical background. When the effect of

reinforcement was determined, it was found that the scores in different ranges were differentially affected by the experimental manipulation (Clingman & Fowler, 1976). Of more important value than the effect obtained was the process uncovered and the additional understanding of the interaction between psychometrics and contingencies of reinforcement.

Examples of the use of operant technology to examine areas previously thought to be confounded by or impervious to the influence of immediate environmental variables are increasing. Whitehead, Renault, and Goldiamond (1975) studied human gastric acid secretion with operant conditioning procedures. Ayllon, Layman, and Kandel (1975) investigated the comparative use of medically prescribed drugs and reinforcement to control hyperactive behavior, often thought to be under the relatively exclusive control of physiological variables. Smith and Lovitt (1973) have demonstrated the remediation of number reversals that were previously thought to be under the control of neurological impairments or immature physiology. In the main, operant technology has been helpful in providing understanding of the extra-organismic processes that interact with many behaviors thought to be under the primary control or organismic variables.

Skinner (1974) points out the lack of utility in discussing the causes of behavior, using instinct related explanations. To say that the duckling follows the mother because of imprinting is not a thorough enough explanation. "Imprinting" as the explanation of "following behavior" eventually becomes accepted

as the cause of the behavior, when, in fact, it is simply explanation at a nominal level. The more subtle effects of the environment are overlooked in this type of analysis.

In much the same way, to say that a student learns visual material best because he has a preference for the visual mode is to explain cause at a nominal level, rather than at a functional level. The further discovery of controlling variables may be undermined by the use of current terminology and explanatory constructs.

In summary, the area of modality preference in children has not been subject to investigation using operant technology. Consequently, the purpose of this study is to investigate the sensitivity of modality controlled performances to environmental variables, thus leading to a fuller understanding of their effect on this phenomenon. Important considerations for this investigation, emerging from the previous review of literature, are the inclusion of non-complex tasks and employment of alternative research strategies.

CHAPTER III

METHOD

In Chapter III the methods and procedures of the study are presented. This includes a description of the subjects, materials and apparatus, settings, procedures, and experimental design. The study was composed of three phases:

1. Identification of eligible children.

2. Identification, using non-complex tasks, of those eligible children meeting criteria for having a modality preference.

3. Application of reinforcement procedures to alleged modality dependent performance.

Subjects

The two subjects were educationally handicapped (EH) elementary students. The subjects were non-retarded and at least one year behind age-appropriate grade level in reading or in arithmetic skills as assessed on the following achievement tests:

a. Slosson Oral Reading Test (Slosson, 1963).

b. Wide Range Achievement Test - Arithmetic Subtest Level I (Jastak & Jastak, 1965).

In order to qualify for the study, the subjects had to know:

a. Names of numbers 1, 2, 3, 4, 5, 6, 7, 8, 9, 0. (Integers 1-0).

b. Consonant vowel consonant (CVC) trigram words. (See Appendix A).

Each child was shown a list of the words and numbers used in the study. They were required to read the material with 100% accuracy. Demographic and academic data are reported on the children qualifying for the study (see Table 1).

Table 1

Demographic and Academic Data

Subject	Age	Sex	Father's Occupation	Appropriate Grade*	Reading Grade	Arithmetic Grade
1	8 yrs. 11 mos.	M	Professional	4.0	4.9	3.0
2	9 yrs. 8 mos.	F	Semi-skilled	5.0	6.2	2.8

*Because academic testing and demographic data were obtained in late summer, appropriate fall grade placement is given as age-appropriate.

Materials and Apparatus

Apparatus and Stimuli

Bisensory digit span task. Integers (1, 2, 3, 4, 5, 6, 7, 8, 9, 0) were randomly assigned to series of digit spans which were four digits in size (see Appendix B). For each series there was a simultaneous audio and visual presentation. The same number could not occur twice within a bisensory presentation.

Bisensory missing units task. CVC trigrams were selected from a list of words (Thorndike, 1931) within the typical subject's reading capability (see Appendix A). Ambiguous words or homophones (son and sun), as well as words of related meaning were eliminated from any bisensory trial. Numbers were also eliminated (ten and six).

Media. Visual stimuli were projected onto a suitable surface and the audio stimuli were provided by a cassette tape recorder (Buhl Programma, Model 616-150) built to operate the projection equipment (Kodak Carousel Slide Projector, Model E-2). The equipment was programmed so that a sound-relay synchronized the auditory and visual presentation in order to deliver them simultaneously. Digits were presented at a rate of one every two seconds on each channel. Because of limitations of the equipment, the visual duration of exposure was .9 second. The auditory duration averaged .6 seconds in length. These presentation times approximate the specifications provided in Ingersoll and DiVesta's (1972) procedure description.

Stimulus sheet. After a bisensory missing units trial, a stimulus sheet (see Appendix C), containing two of the three words from the auditory and two of the three words from the visual presentation, was placed in front of the subject. A cover sheet with a 175 mm. x 12 mm. opening was placed on top of the stimulus sheet. In this fashion, after each trial, the experimenter would slide the cover down the stimulus sheet in order to expose the proper set of

stimulus words, one set at a time. A complete description of the arrangement used in programming the trials is given in Appendix D.

Reinforcing Stimuli

Nickels were chosen as the reinforcer. This particular currency was chosen because of its generalized value and ease of handling. Nickels were given to the subjects for emitting the appropriate response upon completion of certain missing units trials. As they were earned, nickels were placed in a clear plastic container in direct view of the subject.

Settings

Subject 1 was enrolled in a private school for learning disabled children. An unused classroom was available for carrying out the experiment.

The classroom was well lighted and air conditioned. The subject was seated at a 106 cm. x 106 cm. table. The projection equipment was immediately to the subject's left and the audio equipment was at the subject's right where it could be controlled by the experimenter. The experimenter was seated to the right of the subject.

The experimenter placed the paper stimulus materials necessary for the missing units task directly in front of the subject. As the subject proceeded from one trial to the next, the experimenter controlled the paper stimulus materials with his left hand while he operated the equipment and recorded responses with his right

hand. The slide portions of the bisensory tasks were projected on a surface approximately 106 cm. in front of the subject.

Subject 2 was enrolled in a special summer program for mildly handicapped children. This program was operated at a laboratory school and a spare classroom was used. The classroom was similar to the one used with Subject 1, except that it was not air conditioned. The experimental arrangement was similar to that of Subject 1.

Procedure

Preliminary Procedure

Bisensory digit span task reliability. Because the bisensory digit span task had only been used with college freshmen, it was necessary to determine its reliability with a younger population. Internal consistency was determined by giving a group of 11 subjects ($\bar{x}$ C.A. = 10 yrs. 5 mos.) ten criterion trials and then forming a ratio of the number of auditory correct responses to the number of visual correct responses for the first five criterion trials and then for the second five criterion trials (see Appendix E). A Pearson product moment correlation resulted in $r = .69$ for these two sets of ratios.

Pilot study. In order to develop and refine the procedures for the actual experiment, a pilot study was performed. Two important outcomes resulted from the pilot effort.

First, the multielement baseline that was used incorporated a verbal command as a discriminative stimulus for the subject. In

other words, the subject was told beforehand whether to attend to the auditory or to the visual stimuli and was reinforced for a correct response. After using this procedure with the pilot subject, it became apparent that it was difficult, if not impossible, to determine whether the instructions or the reinforcement schedule controlled the subject's responding. Consequently, in the actual experiment the instructions were eliminated and only the reinforcement schedule was used to influence responding.

The second outcome was the attainment of a recoverable baseline condition that required a relatively large number of trials before the experimenter observed stability. This was in contrast to the smaller number of trials necessary to observe stability in the original baseline phase. This outcome alerted the experimenter to the possibility of using a larger number of trials than was anticipated originally. In fact, many trials were necessary in order to gain stability in a number of phases during the actual experiment.

Experimental Procedure

Reinforcement. After the modality classification and missing units task baseline were obtained, each subject was asked, prior to the actual contingent use, if he or she would like to earn nickels. Both subjects responded emphatically that they would.

Bisensory Tasks. In the digit span task, the subject received ten trials during which he or she was told beforehand from which modality to recall first. These responses were not recorded; they served to familiarize the subject with recall by modality set.

Five additional trials were given and the subject was told to recall whichever set first that he or she wanted. Performance on these five trials served as the modality preference criteria. The subject dictated the numbers recalled and the experimenter recorded the responses. The number of visual correct responses were subtracted from the number of auditory correct responses and a $\pm$ 3 value served to classify the child as having either a visual or auditory preference.

This session was followed by the missing units trials. The different words (CVC trigrams) were presented simultaneously in the auditory and visual modes. The subject received trials until he achieved six correct auditory or six correct visual responses in any group of ten trials. If the subject achieved the six correct responses in the mode corresponding to his classification on the digit span task, then he was said to demonstrate a significant aptitude treatment relationship. The next series of trials was used for reinforcement and the final series of trials comprised the return to baseline condition. The subject saw both sets of words, less one, on a stimulus sheet after each trial (see Appendix C). In order to avoid problems with motor variables, the subject was required to respond orally with the missing word. The experimenter recorded the responses.

A detailed summary of the experimental procedure is as follows:

1. The student was screened in order to determine if he or she met the criteria for word and number recognition and for educationally handicapped classification.

2. Subjects meeting the requirements for the experimental

population were given ten bisensory digit span trials. The subject was told from which modality to recall. Verbatim directions are provided in Appendix F.

3. The subject was given the five criterion trials (see Appendix F). If he met the criterion for having a modality preference, he proceeded to the next task.

4. The subject engaged in bisensory missing units trials (see Appendix F). If he did not reach criterion on this task he was dismissed. If criterion was reached, the subject proceeded to the next series of trials. In these trials the experimenter announced that reinforcement would be given for correct recall of the missing units. The criteria for reinforcement was shifted from the non-preferred to the preferred modality until the experimenter could demonstrate control over responding in both. The subject was not told when the criterion shifted, thereby permitting an assessment of the contingencies alone as an independent variable.

5. After completion of the reinforcement trials, the subject received the third and final series of missing units trials. For this series the experimenter announced that reinforcement would no longer be given for correct recall of missing units.

In summary, seven children, in addition to the 11 children necessary for the digit span reliability procedure, were screened. The pilot subject came from the group of 11 reliability subjects. Three other subjects, who were qualified for the study, were found in the additional group of seven. One subject was dismissed because of a procedural error related to verbal commands given by

the experimenter. The two subjects who remained were employed in the present study. Therefore, 18 children were screened, four were found to be qualified, and two were used for the actual study.

Experimental Design

The design is a single subject reversal type (Baer, Wolf, & Risley, 1968). The first phase was the baseline of bisensory missing units trials. The second phase was the series of missing units trials on a multielement baseline (Sidman, 1960) that consisted of two concurrent discriminated operants, each on a continuous reinforcement (CRF) and extinction multiple schedule. The experimenter systematically applied the reinforcement contingency to responses requiring either auditory or visual attending. This resulted in the visually discriminated operant coming under CRF, while the auditorily discriminated operant came under extinction and vice versa. If the subject was classified as having an auditory preference then the first condition in the second phase consisted of reinforcement for visual responses. If the subject was classified as having a visual preference then the first condition in the second phase consisted of reinforcement for auditory responses. The conditions in the second phase were alternated until the return to baseline phase.

The multielement baseline controls for intertrial difficulty and practice effects by distributing the requirement for responses to any particular modality across a large number of trials. The

multielement baseline also provides the opportunity for repeated demonstrations of experimental control.

Dependent Variables

Two classes of dependent variable were necessary for this study. The first class was the type and number of responses, i.e., number of correct words recalled from each channel on the missing units task and number of incorrect responses. Because an incorrect response could not be assigned to either a visual or auditory mode, incorrect responses were not used to determine accuracy of responding. They served, however, as an indicator of difficulty.

A second class of variable, which was necessary for a fine-grain analysis of the experimental conditions was response latency (Alba, 1975; Ferster & Skinner, 1957). These latencies were recorded for visual, auditory, and incorrect responses. Response latency was defined as the time from offset of the missing units task presentation to the onset of the subject's response.

Data Collection

The data were collected during experimental periods approximately 30 to 45 minutes in length. The subjects' responses were recorded on the experimenter's record sheet for the digit span tasks and the missing units tasks (see Appendix G). Additionally, each session was recorded on audio tape in order to permit measurement of response latencies and checks on reliability.

The latencies, while somewhat difficult to record during the actual experimental sessions, were obtained from the tapes not only by the reliability observer, but also by the experimenter. The latencies were obtained in this fashion, because the time required to time and record the latencies would have slowed down the experimental sessions and limited the number of trials that could be given during any particular session. Additionally, the overt timing may have produced reactivity on the part of the subjects.

The experimenter and reliability observer listened to the tapes and obtained response latencies by starting and stopping a 1/10 second stopwatch at the offset of the bisensory presentation equipment and at the onset of a response. The point of offset was indicated on the tape by the distinct noise occurring when the experimenter operated controls that stopped the equipment. Listeners stopped timing when the subject made an audible response. Latencies were recorded on the experimenter's record sheet.

Data Analysis

The number of auditory, visual, and incorrect responses was plotted using, for each subject, a cumulative graphic display. The cumulative records were subjected to visual inspection as the primary analytic method. The trends in the data from phase to phase and from condition to condition within a phase were used to evaluate the reinforcement effect. The percent of visual, auditory, and incorrect responses in any particular phase or condition was

computed in order to yield a simple quantification of the subjects' response. This information is used to supplement the data in the cumulative records.

The latency data were used to further compare and contrast differences between correct and incorrect responses across the various phases of the experiment. These data are displayed as distributions on a logarithmic scale. The logarithmic scale aids in interpretation because it assists in normalizing the display of the data.

Interobserver Reliability

The reliability procedure chosen for this study was the relatively stringent point-by-point agreement method (Kelly, 1977). It is possible to use the point-by-point method with trial and latency data by recording latency values and codes for various responses within the experimental conditions.

In the present study any trial could be coded as having produced a visual (V), auditory (A), incorrect response (I), experimenter error (EE), or equipment malfunction (EM) (see Appendix E). In order to permit proper coding, the reliability observer was given a copy of the correct auditory and visual answers for any set of trials to be evaluated. The observer listened to audio tapes of the various experimental conditions and recorded response codes accordingly.

After the response codes of the reliability observer were recorded, they could be compared to the corresponding experimenter

records. The point-by-point agreement was computed by dividing the number of specific notations of the observers' records agreed on by the total number they both recorded plus the number of notations only one or the other recorded (Kelly, 1977).

The latency data were checked for reliability in the same manner as the trial notation data. The point-by-point computational procedure was the same. Rather than computing the number of notations agreed upon, the number of latency values agreed upon becomes the unit for reliability evaluation. When determining agreement between two observed latency values, a $\pm$ .5 second observer error was permitted.

CHAPTER IV

RESULTS

The measures used for analysis of the experimental results are the cumulative number of responses and response latencies. The three types of responses were auditory (A), visual (V), and incorrect or error (I). For each type of response, the durations of the response latencies were measured.

In the following sections, both the number of responses and response latencies are analyzed across phases, beginning with the baseline phase (B_1) and proceeding through subsequent phases in which reinforcement was contingent on auditory or visual responses. The subscript indicates the particular order and position a baseline or reinforcement phase held within the experiment. For example, phase V_2 indicates that reinforcement was provided for visual responses and that this was the second such reinforcement phase for the subject. The missing units task raw data, indicating trial numbers, phase changes, and day changes are found in Appendix E.

The data were collected according to the following schedule:

Trials, Phases, and Day Sequence Per Child

Subject 1			Subject 2		
Trial Number	Phase	Day Number	Trial Number	Phase	Day Number
1-39	B_1	1, 2	1-68	B_1	1, 2
40-151	V_1	2, 3	69-106	A_1	3, 4
152-174	A_1	3, 4	107-226	V_1	4, 5, 6
175-201	V_2	4	227-274	A_2	6
202-213	A_2	4	275-295	V_2	6, 7
214-238	V_3	4, 5	296-330	A_3	7
239-264	B_2	5	331-498	B_2	8, 9, 10

Reliability

Table 2 provides percentage agreements between the experimenter and the reliability observer for each experimental condition. Agreement information is shown for each dependent variable, i.e., type of response and response latency. The minimum acceptable total agreement percentage for type of or latency of response was 80%.

For Subject 1, certain conditions, notably B_1, V_1, A_1, and V_3, produced low agreement percentages for either response type or response latency. These low percent values are due, in part, to background noise on the tapes. These noises were present because of air conditioning sounds and occasional interruptions by custodial staff. The raw data taken from the trials that were rated for reliability are provided in Appendix E.

Table 2

Percentage Interobserver Agreement for Dependent Variables Across Experimental Conditions

	Subject 1							
Phase	B_1	V_1	A_1	V_2	A_2	V_3	B_2	Total
Response Type	72.7	76.4	100.0	91.6	NA*	83.3	87.5	87.3
Response Latency	81.8	82.3	78.2	83.3	NA*	75.0	81.2	80.5
	Subject 2							
Phase	B_1	A_1	V_1	A_2	V_2	A_3	B_2	Total
Response Type	92.5	100.0	93.7	96.2	100.0	100.0	100.0	98.3
Response Latency	92.5	76.4	81.2	92.3	95.4	89.4	100.0	90.0

*Not available

Analysis of Cumulative Responses

The responses are displayed by the use of cumulative records (Ferster & Skinner, 1957; Skinner, 1968). The cumulative record was chosen as the display method, because it offers a potent technique for establishing functional relationships between environmental variables and behavior (Alba, 1975). Consequently, for each experimental condition, the type of response is graphed cumulatively by trials. The actual calendar day is noted on the upper part of the auditory grid. Broken vertical lines indicate the trial preceding a day change and the solid vertical lines indicate the trial preceding a phase change. The cumulative graphs are found in Appendix H.

During the course of the experiment, there were occasional experimenter errors and equipment malfunctions. In order to clearly represent every trial outcome, these errors are noted by a break in the cumulative record line at the point that the error or malfunction occurred.

It should be noted at the outset that the steepest slopes possible for the cumulative displays of this experiment are approximately 45 degrees. A 45 degree slope would represent the occurrence of one response per trial for any given response type. Because of the design of the experimental trials, only one response of any particular type is possible. Slopes of less than 45 degrees indicate a lower number of responses across trials and horizontal cumulative record lines indicate no responding across trials. Additionally, after 20 cumulative responses occur, the cumulative record line resets and starts again on the zero line. The continuous record from trial to trial clearly illustrates steady state responding, transition states, and any local fluctuations in the general trend of the data.

Analysis of Baseline 1

An analysis of the performance of Subjects 1 and 2 during the B_1 phase (see Appendix H-1 and H-4) yields a major difference in type of response. Subject 1 strongly responds with auditory responses, while Subject 2 responds with visual responses. These responses reflect their original modality preference classification. There appears to be a steeper cumulative response curve for Subject 1's auditory responding than for Subject 2's visual responding.

While responses to non-preferred presentation modalities also differ as to total number between subjects, the differences in incorrect responding for each subject can likewise be appreciated. Subject 2 makes incorrect responses approximately two times as often as Subject 1. This high error rate probably contributed to Subject 2's extremely low number of responses to the auditory presentation, her non-preferred presentation modality. Furthermore, because of the high number of errors, almost twice as many trials were necessary in order to gain a relatively stable baseline before beginning the reinforcement phases.

Analysis of Reinforcement Phase

The first reinforcement phase (V_1) for Subject 1 consisted of continuous reinforcement for any response that was under the stimulus control of the visual portion of the bisensory presentation. This was Subject 1's non-preferred modality. The first reinforcement phase for Subject 2 (A_1) was arranged in a similar fashion, i.e., reinforcement for the non-preferred modality. Subject 1, possibly because of a high rate of auditory responding during baseline (B_1), persisted in high auditory responding for approximately 50 trials before the contingency began to exert control over the visual responses. In contrast, the reinforcement contingency in Phase A_1 appeared to influence Subject 2's responding after approximately 14 trials.

In order to further clarify the subjects' response patterns, percentage measures of each subject's responses are provided in Table 3. The number of responses in a phase for each of the three

Table 3

Percent of Responses Across Trials
by Response Type and Experimental Phase

Subject 1

Phases	B_1	V_1	A_1	V_2	A_2	V_3	B_2
Auditory*	61.0	40.5	68.1	11.5	66.6	16.6	64.0
Visual*	17.9	35.1	18.2	61.5	16.6	54.2	20.0
Incorrect*	35.8	29.7	22.7	30.7	16.6	33.3	20.0

Subject 2

Phases	B_1	A_1	V_1	A_2	V_2	A_3	B_2
Auditory*	07.0	45.9	43.5	57.1	33.3	58.8	47.8
Visual*	29.5	08.0	24.2	33.3	61.9	23.5	26.6
Incorrect*	60.6	37.8	27.1	19.0	09.5	26.4	23.6

*Subjects occasionally would give both a correct auditory and visual response, and subjects would periodically give no scorable response. Because of these responses, sums of auditory, visual, and incorrect responses, if computed, give values somewhat above or below 100% depending on the particular phase.

response types was divided by the number of trials in that phase. This measure yields an index of response proportion.

When inspecting incorrect response percentages, it becomes clear that Subject 2's A_1 responses took place at 37.8%, about half of the B_1 amount of 60.6%. This reduction of errors is related to the relatively large, sixfold, increase in auditory responses. The increases in non-preferred responding from the B_1 to V_1 phase for Subject 1 and from the B_1 to A_1 phase for Subject 2 argue convincingly for the existence of a functional relationship between the reinforcement contingency and bisensory missing units task performance. It must be kept in mind that the auditory V_1 value for Subject 1 is relatively high because of the large number of trials that elapsed before the contingency had an effect on visual responding. From trial 100 to 150, however, the rapid changeover can be appreciated easily.

Returning to the cumulative displays, it is interesting to note, during the V_1 phase, Subject 2 persisted for a large number of trials in auditory responding. Around trial 228 the visual responding began to increase. For Subject 2 the large number of trials necessary to gain control of the visual responding and to note a reduction in auditory responding contributed to the high V_1 auditory value found in Table 3.

Weiner (1970) discusses the existence of behavioral persistance in human subjects. He has attributed this behavior to either organisms with limited response repertoires or to uncontrolled variables affecting performances. Because Subject 2 had both

auditory and visual responses in her repertoire, the possibility exists that during the V_1 phase an uncontrolled variable was operating. In either event, responding did come under control dependably from trial 228 through trial 252 and, in those 24 trials, 75% of the responses were visual.

Except for a slow changeover in condition V_1, experimental control was demonstrated consistently for Subject 1 in phases V_2, A_2, and V_3. The trend in responding was quickly brought under control by the reinforcement contingency, and consequently fewer trials were needed to obtain stability in these phases.

Subject 2 performed in a similar manner but with some variation. Upon close inspection of phase A_2 and V_2 it can be seen that the effects from a previous phase carried over as much as 14 trials in the following phase, as illustrated by continued visual responding from phase V_1 to A_2. For Subject 1, there were virtually no occurrences of behavioral persistence in the latter phases (A_1, V_2, A_2, and V_3) for either auditory or visual responses.

Analysis of Incorrect Responding

Incorrect responding served as an indicator of difficulty of the material in any particular phase. As previously mentioned, the number of incorrect responses cannot be computed with the number of correct responses to provide measures of accuracy, because of the difficulty in reliably determining whether any particular incorrect response was visual or auditory in nature. An interesting pattern, however, appears from phases A_2 through B_2 in Subject 2, and from phase V_1 through B_2 in Subject 1. For the phases noted,

when reinforcement was applied to performances in non-preferred learning modalities, the incorrect responses increased (see Table 3). When reinforcement was applied to performances in preferred learning modalities, then incorrect responses decreased. It must be kept in mind that this pattern is related to difficulty but not accuracy of responding. Furthermore, there were no contingencies placed on incorrect responses in any phase of the experiment.

Analysis of Baseline 2

The final return to baseline (B_2) phase for each subject yielded contrasting results. Subject 2 initially gave a brief run of visual responses from approximately trial 65 to trial 80, while auditory responding decreased during the same period. After this set of trials, however, Subject 2 engaged in continued auditory responding. As noted in Table 3, error percentages during B_2 responding were not especially high. In fact, errors occurred two thirds less often than during the B_1 phase.

Subject 1 quickly regained the original response curves observed during the B_1 phase. Briefly returning to the pilot study, the pilot subject, classified like Subject 1 as having an auditory preference, demonstrated a similar recovery of baseline responding. During the pilot study, however, the recovery of the auditory preference occurred after 50 trials of baseline. In other words, the data would have appeared to recover the original B_1 visual stability; when in actuality, a transition or local fluctuation was in effect (see Appendix H-7, H-8).

Regarding the B_2 phase, it is necessary to keep in mind that the multielement baseline design, by permitting the repeated demonstration of experimental control, usually diminishes the need for returning to a lengthy baseline condition. Because only one more affirmation of the consequent (Sidman, 1960), showing that the independent variable was responsible for the change in responding, is gained, the additional expenditure of time may not always be justifiable.

When, after numerous experimental manipulations, irreversability is encountered, Sidman (1960) points out:

> If non recoverability is indeed a fact, intrasubject replication is not possible. I have brought up the consideration, however, that the irreversability may be elsewhere than in the organism or in his behavior. . . . The extinction operation, as it is normally carried out, only destroys some of the relations that were established during original acquisition. (pp. 101-102)

Because of numerous experimental manipulations of Subject 2's baseline performance, the possibility exists that the irreversability encountered is a function of environmental variables and not organismic ones. If this is true, then the baseline condition could, no doubt, be recovered had further experimental manipulation been attempted.

In the main, the three replications (V_1, V_2, V_3) with Subject 1, and the three replications (A_1, A_2, A_3) with Subject 2 argue convincingly for the existence of a functional relationship between the contingencies of reinforcement and both subjects' performances on the bisensory missing units task. With few exceptions, experimental control was demonstrated across both subjects in a relatively rapid and predictable fashion.

Analysis of Response Latencies

Response latencies were graphed as distributions on semi-logarithmic scales. Latencies are displayed for each type of response (A, V, and I) by phase. These displays are provided in Appendix I. Means of the latency distributions are provided in Table 4.

Response latencies did not prove to be greatly responsive to the experimental manipulations. Consequently, few reliable generalizations can be made from the latency data. There are, however, a number of trends that became apparent upon close inspection of the data.

For most conditions, the duration of latencies associated with incorrect or error responses was uniformly high across both subjects. The only example of an auditory or visual latency higher than incorrect latencies occurred once during Subject 2's visual B_1 performance (see Appendix I-4). With that exception, Subject 2's incorrect latencies were consistently higher than any latencies obtained for auditory or visual responses. High latencies associated with incorrect responses have also been noted by Alba (1976) in work involving the use of time parameters for investigation of academic responding.

In the majority of measures a relatively high auditory or visual response latency occurred during reinforcement conditions. Overall means for baselines and reinforcement conditions are noted in Table 4. The visual overall mean for Subject 1 provides the only overall measure wherein the baseline mean is greater than the

Table 4

Latency Means by Response Type and Experimental Condition

Subject 1	B_1	V_1	A_1	V_2	A_2	V_3	B_2	Overall Mean B_1,B_2	Overall Mean V_1,A_1,V_2,A_2,V_3
Auditory	1.68	3.00	2.12	4.90	NA*	.00	2.59	2.12	3.34
Visual	2.12	1.60	1.15	4.00	NA*	2.87	2.78	2.45	2.40
Incorrect	3.00	3.90	2.98	8.50	NA*	6.80	2.59	3.25	5.54

Subject 2	B_1	A_1	V_1	A_2	V_2	A_3	B_2	Overall Mean B_1,B_2	Overall Mean A_1,V_1,A_2,V_2,A_3
Auditory	1.50	2.39	3.52	4.40	4.83	3.17	3.32	2.41	3.66
Visual	1.59	.80	3.75	3.10	3.70	2.25	2.58	2.08	2.72
Incorrect	.99	1.89	5.20	5.18	9.10	5.17	3.49	2.24	5.30

*Not available

reinforcement mean. It should be noted, however, that these two measures are very similar in value. Relative to means for individual conditions, those means representing latency measures during reinforcement conditions exceeded baseline measures in 18 out of 26 conditions (70%). The shift in latency duration also carried over into the B_2 condition for both subjects. The carry over was more noticeable for Subject 2 than for Subject 1. For Subject 2, the clarity of the greater latencies in the B_2 phase may also be a reflection of larger amounts of data gathered in this condition. Regarding individual latency values, the exception to hiqher latencies during reinforcement was again the one outlying latency in the visual B_1 condition for Subject 2 (see Appendix I-4).

Relative to individual incorrect latency values, Subject 2's B_2 latency durations exceeded those of the B_1 condition (see Appendix I-4 and I-7). The longer individual latencies found under reinforcement were not found for incorrect responses in Subject 1 (see Appendix I-1 and I-3). The data might be better understood when one considers a possible source of short latencies in general.

It was noted during the baseline trials that Subject 2 engaged in frequent guessing, to the extent that this particular subject might give a response before the stimulus sheet cover was moved to expose the appropriate stimulus words for the trial. As the experiment proceeded this behavior decreased, no doubt, because of its limited reinforcement. The final product, however, of guessing behavior was incorrect responses and short latencies. As Subject 2 was exposed to various reinforcement conditions, guessing stopped and the duration of latencies increased.

In attempting to understand greater latencies, when careful inspection of the latency data during reinforcement is made, it is possible to note a trend for latency durations to cluster around greater time values. The clustering is noticeable for the type of response being reinforced. In other words, with two exceptions, visual latencies were at least as long if not longer than auditory latencies under visual reinforcement conditions. The V_3 phase for Subject 1 resulted in no auditory responses thereby eliminating this phase from the above comparisons. The trend to longer latencies under various reinforcement conditions might be indicative of the more careful attempt on the part of the subject to respond correctly.

The experimenter would occasionally hear both subjects employ a rehearsal strategy. This strategy consisted of audible stimulus item repetition taking place while the subject looked at the stimulus sheet. The process of stimulus item repetition, while determining the missing unit, probably required somewhat more time than other non audible strategies. In either case, it became apparent that both subjects at some points in the experiment would use audible verbal rehearsal strategies requiring more time between the offset of the bisensory presentation and the onset of their responses.

An additional subtle relationship was noted in Subject 1's data. At one point, the experimenter ran out of reinforcers for Subject 1. The problem occurred during the V_2 phase. At this time the experimenter substituted (as the medium for reinforcement) check marks on a card rather than nickels. The card was to be traded in for cash during the following session. Although it is

difficult to make an experimentally verifiable statement, this phase produced, as a whole, somewhat longer latency durations for all three categories of responding (see Appendix I-2). Further replications, however, would be needed to clarify any reliable functional relation between latency and change in the reinforcing stimulus.

In sum, the most convincing data that a functional relationship exists between the subject's performance and the reinforcement contingency are found by visual inspection of the cumulative response data. The latency data, while serving to clarify subtle characteristics of the responses, are secondary to the large effects and numerous direct replications (Sidman, 1960) of experimental control over the subjects short term memory performance on the bisensory missing units tasks.

CHAPTER V

DISCUSSION

There has been a great deal of interest in modality preference as a learner characteristic and its relation to learner performance. To the extent that it is difficult to determine consistent auditory or visual modality preferences, some investigators (Ingersoll & DiVesta, 1972), nevertheless, claim that aptitude treatment interactions between modality preference and presentation mode indicate preferences which are stable across tasks. Additionally, they claim that these preferences control the subject's performances on a short term memory task.

The present study employed operant techniques to further clarify the variables that act to control alleged modality dependent performances with mildly educationally handicapped children. A positive reinforcer proved to control the modality related performances of these children. This demonstration provided an illustration of the environmental variables contributing to the consistency of modality preference, and subsequently provides an explanation for a subject's performance at a functional level, rather than at a nominal level.

Findings

The findings of this study are discussed relative to the experimental questions. The questions are listed and a brief discussion follows.

1. Is there a functional relationship between contingencies of reinforcement and short term memory performance, allegedly under control of a visual modality preference?

The data drawn from Subject 2, who was classified as having a visual preference,indicate that the reinforcement effect, while not always similar in pattern from phase to phase, was present. Visual inspection of the cumulative response curves demonstrates, especially at phases A_1, A_2, V_2, and A_3, consistent control over the type of responding.

Data from Table 3 indicate that contingencies, when placed on auditory responses, increased percent response values over those obtained during both the visual baselines. Except for phase V_2, auditory values, obtained when reinforcement for visual responding was in effect, exceeded those values obtained for visual responding. In other words, the application of reinforcement increased performance in the non-preferred modality to the extent that it exceeded performances in the preferred modality with one exception. Increased performance is visible for auditory responses in phase A_1 and A_3, when compared to visual responses in phases B_1, B_2, and V_1.

Visual latencies for Subject 2, who exhibited a visual preference, were not greatly sensitive to reinforcement when

applied to specific classes of response. In other words, when auditory responses were reinforced there were no easily discernible shifts in the auditory latency distributions. Thus, for the present study these measures are equivocal in there sensitivity to the independent variable.

2. Is there a functional relationship between contingencies of reinforcement and short term memory performance allegedly under control of an auditory modality preference?

Visual inspection of the trends in the cumulative records indicates relatively reliable control over the direction of the response curves.

The data gathered on Subject 1 indicated that he exhibited an auditory preference. When reinforcement contingencies were placed on visual responding, the percent value not only doubled its B_1 value (see Table 3), but also, in two out of three visual reinforcement phases (V_2 and V_3), exceeded the B_2 auditory condition. Further, the visual responding under visual reinforcement exceeded or approached, within 6.8%, the B_1 auditory responding, in phases V_2 and V_3.

As with Subject 2, Subject 1 when under reinforcement for the non-preferred class of response, did not demonstrate changes of a noticeable magnitude on the latency measures for the non-preferred response. Therefore, the usefulness of these measures for addressing the second experimental question is limited.

Supplementary information, not directly related to the experimental questions, bears some discussion. First, although the

latency measures did not prove especially sensitive to the specific experimental manipulations per se, the latency data did seem responsive to reinforcement conditions in general. Second, latency measures did provide data useful for a topographical analysis of the responses. As mentioned earlier, subjects' responses that were characterized best as guesses exhibited extremely short latency durations. Longer response latencies, for correct responding, appeared to take place on occasions characterized by a subject's use of a vocal or almost subvocal rehearsal strategy. Incorrect responses were characterized by latencies frequently approaching or exceeding a ten second value. For correct responses, time values exceeding ten seconds only occurred twice out of 13 possible phases in which the latency datum was kept. Third, that the incorrect responding was differentially sensitive to experimental phases is suggested by the data in Table 3. Because incorrect responding cannot be clearly identified with any response type, it is of little use in discussing the subjects' accuracy. It does, however, provide an indicator of differential difficulty for the subjects.

Interpretation of the Findings

That a functional relationship between the type of responses on the missing units task and contingencies of reinforcement exists is clear. Interpretation of the data at a molecular level was provided in Chapter IV. At a molar level, interpretations of the experimental findings, relative to Ingersoll and DiVesta's (1972)

suppositions of modality preference control and stability, are necessary.

Ingersoll and DiVesta (1972) observed their subjects' performances on a bisensory task and then observed similar performances on another set of bisensory tasks. From this set of observations they proceeded to suggest a causal relationship between preference and performance. Realistically, the relationship observed could be categorized as correlational. To say one set of behaviors indicates control over another is to make a statement needing a strong experimental foundation.

First and foremost, the repeated demonstrations of a relatively weak reinforcer as an independent variable capable of controlling which of two discriminated operants a subject would use most frequently, certainly places the question of control in a functional perspective, rather than a correlational one. The numerous experimental manipulations using an independent variable under control of the experimenter would appear to be a more viable method to approach the questions as to what, in fact, might control a subject's bisensory short term memory performance.

Bearing on modality preference stability, the inference made by Ingersoll and DiVesta (1972) that the observed aptitude treatment interaction in their study implied stability or consistency across tasks is certainly reasonable. Stability from one task to another, however, implies stability through time. The point is of moment, because Ingersoll and DiVesta performed their tasks in sequence. The modality preference identification task was performed first and the missing units task second. The data in the present experi-

ment give support for relative flexibility of response direction through time. Additionally, Subject 2 did not recover the original baseline responding she demonstrated earlier on each modality, but showed a pattern of alternating between both.

Whether or not responding could be recovered is not as important as the fact that it did change and remained so after experimental manipulations ceased. This is even more interesting in light of Subject 2's performance on the bisensory digit span task. Subject 2 scored the greatest value (-12) in the visual direction of any child screened for the study. If the visual modality preference was truly stable or consistent across these tasks, then it seems likely that the baseline condition would have been recovered, at least partially. It must be kept in mind that Ingersoll and DiVesta (1972) concluded that extreme digit span scores would be associated with clear response patterns on the bisensory missing units task. The validity of this proposition may be restricted when one considers the data of the present experiment.

Smaller incorrect response magnitudes did appear in phases under reinforcement for responses similar to the original modality preference classification; nonetheless, there is little reason to believe that experimental control of incorrect responding in any phase could not be achieved given the appropriate experimental controls.

In sum, regarding control of alleged modality dependent performances and their stability across tasks, it appears that the source of control for a subject's performance is more likely to

be found in specifiable, measurable, and for the most part, controllable variables such as positive reinforcement, in the immediate learning environment. Resorting to explanations based on data essentially correlational in nature has very limited utility in uncovering the variables responsible for behavior. Stability across tasks is very likely to be a function of these same variables acting in concert with time parameters.

Problems and Limitations of the Study

The foremost limitation of any study performed in the area of modality preference is the instrumentation and criteria used for modality preference identification. The second pressing problem is the provision of a treatment that actually possesses the components for classification as exclusively auditory or visual in nature.

Relatively non-complex tasks were chosen to minimize the threats of both foregoing limitations. The use of non-complex tasks may have limited generality to the domain of tasks that are primarily the focus of modality based treatment, i.e., reading. Short term memory, on the other hand, has been suggested as a skill necessary for reading (Senf, 1969). Consequently, the tasks used for the modality treatment in this study may be components of more complex behavior.

A problem that deserves some discussion, because it is noticeable with Subject 2, concerns equipment malfunctions. The precision of the equipment was limited. Changes in available line voltage and even changes in temperature would periodically effect the

performance of the audio-cassette sound relay that controlled the visual portion of the bisensory presentation. The effect of the occasional interruptions is not known. Fortunately, the greatest proportion of trials took place without interruption. This problem could be avoided in future studies by the use of more sophisticated programming equipment.

The second problem was the behavioral persistence encountered with Subject 2. The possibility exists that an uncontrolled variable (Weiner, 1970), such as subtle cues by the experimenter, accidental reinforcement, or a practice effect, contributed to the observed persistence. Additionally, in any study there is a chance that the subject reaches a state of reinforcer satiation or that the reinforcer itself may have been identified incorrectly. In any operant study of reinforcement the only control for these possibilities is inspection of the data. Control was achieved eventually in all experimental conditions, but the possibility that a loss of reinforcer effectiveness or, on the other hand, a competing reinforcer during certain trials remains. In either event, it is worthy to note that the persistence took place in the subject's auditory response, her non-preferred modality. This fact subsequently limits the value of an auditory preference as a plausible alternative explanation.

Practical Implications

A number of outcomes in this study have practical implications for those involved in research or applied work. First,

methodologically, the value of a dynamic or continuous measurement strategy, an integral component of operant technology, becomes evident. The continuous measurement through time employed in this study permitted the investigator to not only note changes in the data that were necessary for making experimental decisions, but also note changes in responding that occasionally might be at variance with the subject's original preferred modality classification. The continuous measurement process could be crucial in programming the most effective modality treatment, had the study been concerned with making an educational intervention based on the subject's modality use.

Second, the direct measurement strategy employed in operant research deserves comment. The data in the present experiment did not undergo a statistical averaging in preparation for tests of significance nor did the primary measurement units evolve from any statistical summarization of the data. For the most part the data was interpreted in units that were compatible with the continuous measurement strategy. In other words, direct measurement procedures are interpreted in a display that reflects each trial outcome and the impact of time as a parameter. For example, had B_1 cumulative data been everaged with B_2 cumulative data in Subject 2, conclusions about her modality performance across tasks would have been entirely different from those originally presented.

Third, for the practitioner of modality based teaching interventions, the data of this study tentatively indicate that modality use in various presentation modes is not undivided. That by using

the proper environmental arrangements performances in an alleged non-preferred modality can approach or in some cases exceed the performance in a preferred modality. This is not to say that performance in non-preferred modes can consistently be equated with performances in the preferred, but the possibility for approximate performances exists.

The error patterns in both subjects showed differential sensitivity to the experimental conditions. In order to increase performance in a non-preferred modality there may be some temporary trade off in terms of error rates, but not necessarily in terms of accuracy. In the response latency measures there were no examples of differential error sensitivity.

There is convincing evidence that to exclude a learner from material presented in a non-preferred mode would be a great injustice and possibly even an inefficient teaching tactic. It may, in fact, be a service to the learner to be switched to a non-preferred modality. Subject 2 used her non-preferred modality frequently in the B_2 condition after exposure to the experimental conditions. Professionals have assumed that the preferred modality is in the service of the learner while at the same time attributing the preference to sensory and other constitutional traits.

It is entirely possible that an individual's observed modality use is a function of his or her past reinforcement history. In this sense a modality preference could be superstitious in origin. In other words, the modality use frequency that one observes in an individual could have come about by accidental reinforcement of

learning in that particular modality. It must be kept in mind that reinforcer control of modality use was demonstrated repeatedly in the present experiment. And, if one considers the term preference in a functional perspective it actually connotes a high probability or frequency of an activity on the part of the individual who exhibits the preference. Thus, modality use frequency is the defining characteristic of a modality preference and reinforcement influences the frequency of modality use. In sum, a learner may perform better in a supposedly non-preferred learning modality than expected, if the consequences for that performance are reinforcing and if the consequences are arranged systematically.

Suggestions for Future Research

The foregoing research, in many ways, stimulates an unlimited variety of questions related to modality preference research. Much research is needed before one can fully understand the relationship of reinforcement to modality related performances.

The first requirement for any science is that of replication, for it is the soundest empirical test of reliability (Sidman, 1960). Operant procedures lend themselves well to replication. Because of the reliance on experimental control, the great number of observations on relatively few subjects, the strategy of holding many variables constant, while manipulating only one, and because of the technologically exact descriptions of the procedure, replication is possible.

Systematic replication (Sidman, 1960) of the present experiment should give a fuller understanding of modality use and related performances. First, replications with children presenting various behavioral repertoires, such as different baseline modality use and error response patterns, is of the utmost importance for understanding the generality of the present results. There is a need to determine, with other children, not only the generality of the functional relations noted in this study, but also the general usefulness of the methods employed.

Second, the complexity level of the task may interact with the subjects' modality use. As noted with Subject 2, incorrect responding took place at a high rate in phase B_1 when compared to Subject 1's responding. Whether or not Subject 2's incorrect responding during baseline contributed to her behavior in the experimental condition is certainly a valid question that can be addressed by investigating various levels of complexity in task arrangements or in stimulus materials.

Third, it is assumed in modality investigations that subjects naturally provide responses associated with that presentation modality that is the most effective for them. In the present study contingencies of reinforcement proved to influence the type of response that a subject gave. It may be of value to investigate variables such as various verbal directions to the subject. It is possible that directions can effectively control performance to the extent that the subjects' optimum performance in a modality can be obtained by instructing them to attend to that modality.

In the same manner, instructing a subject in various rehearsal techniques may also optimize their learning in an infrequently used modality while also increasing the chances for increased use of that modality.

Fourth, the schedule of reinforcement in the present study was continuous. The area of schedule effects on modality use should be systematically investigated. Not only the schedule effects of reinforcing stimuli, but also the schedule effects of aversive stimuli could prove valuable as a research area. Schedule research with both types of stimuli could illuminate behavioral processes contributing to particular modality use patterns.

Fifth, in the present study accuracy of responding was difficult to evaluate. Further studies of a similar nature should concentrate on the accuracy of a subject's response under varying reinforcement conditions. In order to carry out such research, techniques need to be developed to determine if an incorrect response is associated with auditory or with visual stimuli.

By performing replications of the present experiment and by pursuing the suggested research, the knowledge base associated with modality preference can expand and ultimately become consumable by the population in greatest need of viable teaching strategies - handicapped children.

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APPENDICES

APPENDIX A

CVC TRIGRAMS

	V			I		
Trial 1	rib	cad	dig	fig	den	dim
2	bet	mar	car	pax	hap	rib
3	bid	cab	beg	fop	but	dam
4	cam	cud	den	fan	gap	jet
5	box	peg	cog	lap	hew	dip
6	tug	new	his	fob	mop	bib
7	gem	cob	bug	dog	bag	dot
8	jag	ham	lot	cap	keg	put
9	rid	bus	fed	bat	gag	pun
10	gat	dad	mix	fog	sin	hod
11	bed	map	jug	don	pug	cut
12	din	lid	lex	sot	run	sad
13	bog	gas	sap	big	get	fit
14	mat	rov	hot	pip	mad	hut
15	bad	fad	ran	gin	hop	hub
16	pet	sod	rug	sac	wig	pit
17	jaw	mot	lip	cat	fix	kid
18	pen	kin	bed	job	can	hip
19	bas	con	sup	cub	nob	she
20	way	ton	log	pot	sop	pap
21	rut	hat	rip	mum	hap	sis
22	dub	wed	had	gut	leg	pin
23	mug	wan	jut	top	pew	set
24	hen	jig	fun	hog	hid	let
25	dab	lit	pod	him	cot	kit
26	mid	hit	rot	rim	tab	bun
27	men	wag	pop	met	jet	lax
28	yet	tot	hip	day	lag	tap

APPENDIX B

DIGIT SPANS

1.	2789	4035
2.	4267	1859
3.	1354	0672
4.	2604	1738
5.	7369	4218
6.	9034	2681
7.	6349	1052
8.	2753	4198
9.	1382	9705
10.	5927	8064
11.	5306	1472
12.	6398	2174
13.	2496	0351
14.	8513	2076
15.	0231	6485

APPENDIX C

MISSING UNITS TASK STIMULUS SHEET

TRIALS 1-28

		V			I	
Trial 1	CAD	DIG	____	DEN	____	FIG
2	CAR	____	MAR	____	PAX	HAP
3	____	BEG	CAB	BUT	____	DAM
4	DEN	CAM	____	FAN	JET	____
5	____	COG	PEG	HEW	____	DIP
6	NEW	____	HIS	MOB	BIB	____
7	____	BUG	GEM	BAG	DOT	____
8	LOT	JAG	____	CAP	____	KEG
9	FED	____	RID	____	BAT	PUN
10	DAD	MIX	____	____	FOG	HOD
11	MAP	JUG	____	PUG	DON	____
12	____	LEX	DIN	____	RUN	SOT
13	GAS	____	SAP	GET	FIT	____
14	HOT	MAT	____	MAD	____	HUT
15	____	RAN	FAD	____	GIN	HUB
16	RUG	____	SOD	WIG	____	SAC
17	JAW	LIP	____	FIX	CAT	____
18	KIN	BED	____	____	CAN	JOB
19	BAS	____	CON	NOB	____	CUB
20	____	LOG	TON	____	POT	SOP
21	____	RIP	RUT	SIS	MUM	____
22	HAD	WED	____	PIN	____	LEG
23	____	WAN	MUG	PEW	____	TOP
24	HEN	FUN	____	____	LET	HOG
25	LIT	____	DAB	KIT	HIM	____
26	____	ROT	MID	RIM	BUN	____
27	POP	____	MEN	____	MET	JET
28	HIP	____	TOT	TAP	LAG	____

MISSING UNITS TASK STIMULUS SHEET

TRIALS 29-56

Trial 29	____	DIG	JIB	DEN	____	DIM
30	MAR	____	BET	RIB	PAX	____
31	CAB	BID	____	____	FOP	DAM
32	DEN	____	CAM	JET	GAP	____
33	COG	BOX	____	HEW	____	LAP
34	____	HIS	TUG	____	FOB	BIB
35	COB	____	GEM	BAG	DOG	____
36	HAM	JAG	____	____	PUT	CAP
37	____	RID	BUS	GAG	____	PUN
38	DAD	____	GAT	HOD	SIN	____
39	MAP	BED	____	____	CUT	DON
40	____	LID	DIN	RUN	____	SAD
41	GAS	BOG	____	____	GET	PIG
42	HOT	____	ROB	HUT	PIP	____
43	____	BAD	RAN	HUB	____	HOP
44	____	SOD	PET	SAC	PIT	____
45	MOT	JAW	____	____	KID	CAT
46	KIN	____	PEN	CAN	HIP	____
47	____	SUP	CON	SAG	____	CUB
48	TON	WAY	____	____	PAP	SOT
49	____	RIP	HAT	HAP	SIS	____
50	WED	____	DUB	____	LEG	GUT
51	WAN	JUT	____	SET	____	TOP
52	FUN	____	JIG	HID	____	LET
53	POD	LIT	____	KIT	COT	____
54	____	HIT	MID	BUN	____	TAB
55	WAG	____	POP	____	MET	LAX
56	HIP	YET	____	LAG	____	DAY

APPENDIX D
DESCRIPTION OF TRIAL PROGRAMMING

Missing Units Task

There were basically 28 unique sets of trials, each containing three auditory and three visual stimuli. The slides necessary for the visual presentation were photographed on reverse black and white film in order to produce a white word with black background when projected.

A 140 slide capacity Kodak slide tray was used. The slides were loaded into the tray in groups of three and a blank space was left between each group. This provision enabled the experimenter to see when the end of any particular trial occurred, because a large white light would appear on the projection surface. This light, resulting from the blank slot in the slide tray, served as a signal for the experimenter to stop the audio cassette which controlled the slide projector. At this point, the experimenter would move the cover sheet in order to expose the stimulus words associated with the auditory and visual stimuli that were just presented.

The two stimulus sheets provided 56 sets of stimulus words. This number was accomplished by varying the missing words from one sheet to the next. Thus, the experimenter could perform 28 trials, with one stimulus sheet (trials 1-28), then reset the audio and visual equipment to start over and use a second stimulus sheet

(trials 29-56) containing different missing words in each trial. Consequently, after 56 trials, the experimenter would start over with the first sheet (trials 1-28).

By using 56 trials, each with a different missing unit, it became very difficult for the subject to memorize answers, even after repeated exposure to the basic 28 sets of auditory and visual stimuli.

Digit Span Task

Fifteen unique sets of digits were photographed on reverse film and placed in an 80 slide capacity Kodak slide tray. These were programmed simultaneously with 15 unique sets of four digits on audio tape. The first ten sets were used for the familiarization trials and the last five sets were used for the criterion trials. As in the bisensory missing units task, a space was left after each set of four slides in order to permit the experimenter time to stop the equipment and record the subject's response. The numbers contained in each set appear on the digit span record sheet.

APPENDIX E

RAW DATA

BISENSORY DIGIT SPAN RELIABILITY RAW DATA

Reliability Subject No.	Age	First Five Trials No. Correct Responses Auditory	Visual	A/V Ratio	A-V Difference	Second Five Trials No. Correct Responses Auditory	Visual	A/V Ratio	A-V Difference
1	10 yrs 1 mo	16	5	3.20	+11	17	9	1.88	+8
2	8 yrs	9	13	.69	- 4	9	17	.52	-8
3	8 yrs 10 mo	14	18	.78	- 4	13	20	.65	-7
4	12 yrs 1 mo	17	12	1.42	+ 5	12	15	.80	-3
5	12 yrs 10 mo	14	18	.78	- 4	17	18	.94	-1
6	11 yrs 1 mo	15	13	1.15	+ 2	15	16	.94	-1
7	9 yrs 1 mo	16	11	1.45	+ 5	15	14	1.07	+1
8	9 yrs 11 mo	10	17	.59	- 7	13	12	1.08	+1
9	10 yrs 11 mo	17	13	1.31	+ 4	13	17	.76	-4
10	14 yrs 5 mo	14	16	.88	- 2	15	12	1.25	+3
11	8 yrs	20	11	1.82	+ 9	18	12	1.50	+6

RAW DATA - SUBJECT 1

Trial No.	Response	Latency (in seconds)	Trial No.	Response	Latency (in seconds)	Trial No.	Response	Latency (in seconds)
---- Start Baseline ----			15	A	1.5	30	I	1.0
---- Start Day 1 ----			16	V	2.1	31	I	4.0
1	I	NA	17	A	1.0	32	A	4.0
2	I	NA	18	I	2.6	33	I	5.0
3	I	NA	19	I	6.0	34	A	1.0
4	A	NA	20	A	2.4	35	I	5.0
5	I	NA	21	I	1.2	36	A	3.7
6	A	NA	22	A	1.0	37	V	1.5
7	V	2.6	23	V	3.2	38	A	1.0
8	A	1.0	24	A	1.0	39	V	1.5
9	V	1.5	25	A	.7	- Visual Reinforce. Starts -		
10	A	1.0	26	A	1.0	40	A	1.0
11	I	1.8	27	V	2.5	41	A	.7
12	I	1.5	28	A	2.4	42	A	2.0
13	A	2.0	----- Start Day 2 -----			43	V,A	1.8
14	A	2.0	29	I	1.0	44	A	2.5

Trial No.	Response	Latency (in seconds)	Trial No.	Response	Latency (in seconds)	Trial No.	Response	Latency (in seconds)
45	I	.5	62	A	1.0	79	A	1.7
46	I	4.5	63	V,A	5.0	80	A	2.5
47	I	2.5	64	A	1.6	81	A	8.0
48	A	1.7	65	I	2.0	82	A	2.2
49	A	3.7	66	A	1.6	83	A	4.5
50	A	1.0	67	A	2.2	84	I	7.2
51	A	.9	68	A	2.3	85	V	3.1
52	V,A	4.1	69	I	6.0	86	A	4.4
53	A	1.0	70	A	5.5	87	A	2.7
54	I	8.6	71	A	3.6	88	V	1.6
55	I	8.0	72	A	4.5	89	I	6.7
56	I	2.8	73	A	2.7	90	I	7.0
57	I	5.5	74	V	1.4	91	A	5.5
58	I	8.6	75	A	2.2	92	A	4.4
59	I	5.0	76	A	1.7	93	V	.9
60	I	3.0	77	V	2.7	94	A	5.0
61	I	4.0	78	I	2.3	95	I	4.6

Trial No.	Response	Latency (in seconds)	Trial No.	Response	Latency (in seconds)	Trial No.	Response	Latency (in seconds)
96	V	2.6	-----	Start Day 3	-----	129	V	1.0
97	V	1.1	113	V	1.5	130	V	1.5
98	A	5.4	114	A	6.0	131	V	1.0
99	A	1.1	115	A	1.2	132	I	.7
100	V	.9	116	A	6.5	133	V	1.5
101	V	1.0	117	I	4.4	134	I	4.0
102	A	1.2	118	I	1.0	135	I	2.3
103	V	.6	119	A	6.7	136	V	2.2
104	V	.9	120	A	6.4	137	V	1.5
105	V	1.0	121	I	1.0	138	I	7.4
106	V	1.5	122	I	6.2	139	A	5.4
107	I	5.2	123	V	4.2	140	V	1.0
108	V	1.9	124	A	5.7	141	V	1.5
109	I	NA	125	V,A	2.4	142	V	.5
110	I	NA	126	A	2.5	143	I	3.8
111	V	NA	127	I	3.0	144	V	1.8
112	V	NA	128	V	1.0	145	V	.6

Trial No.	Response	Latency (in seconds)	Trial No.	Response	Latency (in seconds)	Trial No.	Response	Latency (in seconds)
146	I	3.6	162	A	.5	177	V	4.1
147	V	.7	163	A	1.7	178	A	5.6
148	V	1.7	164	A	.7	179	I	8.0
149	V	.6	165	A	.5	180	V	3.2
150	V	1.6	166	I	1.4	181	I	9.2
151	V	1.8	167	A	2.0	182	V	3.0
-- Start Auditory Reinf.--			168	A	3.3	183	V	4.6
152	V	1.5	169	A	1.9	184	I	13.5
153	V	.8	170	I	1.9	185	V	5.0
154	A	1.6	---- Start Day 4 ----			186	I	8.0
155	V,A	1.4	171	I	5.6	187	I	7.0
156	V	1.0	172	A	4.0	188	V	3.0
157	A	1.4	173	A	2.7	189	V	5.4
158	A	.6	174	A	3.2	190	V	4.5
159	A	.5	- Start Visual Reinf. -			191	V,A	5.1
160	I	4.2	175	A	4.1	192	·V	3.2
161	I	1.7	176	I	7.5	193	I	4.6

Trial No.	Response	Latency (in seconds)	Trial No.	Response	Latency (in seconds)	Trial No.	Response	Latency (in seconds)
194	I	10.0	210	A	NA	226	I	NA
195	V	5.2	211	A	NA	----- Start Day 5 -----		
196	V	3.5	212	A	NA	227	V	4.0
197	V	3.9	213	A	NA	228	V	3.6
198	V	2.6	-- Start Visual Reinf. --			229	I	7.0
199	V	NA	214	A	NA	230	I	9.2
200	V	NA	215	A	NA	231	I	4.6
201	V	NA	216	I	NA	232	V	2.1
- Start Auditory Reinf. -			217	A	NA	233	V	3.6
202	I	NA	218	I	NA	234	V	2.1
203	V	NA	219	A	NA	235	V	3.2
204	V	NA	220	V	NA	236	V	2.6
205	A	NA	221	V	NA	237	V	2.9
206	A	NA	222	V	NA	238	V	2.0
207	A	NA	223	I	NA	--- Start Baseline ---		
208	A	NA	224	I	NA	239	I	2.8
209	I	NA	225	V	NA	240	I	3.5

Trial No.	Response	Latency (in seconds)	Trial No.	Response	Latency (in seconds)	Trial No.	Response	Latency (in seconds)
241	A	1.6	249	A	5.2	257	A	3.0
242	A	3.9	250	A	1.2	258	I	4.0
243	A	3.2	251	V	3.6	259	V	1.0
244	V	3.5	252	A	3.0	260	A	3.0
245	A	1.5	253	V	2.5	261	A	3.7
246	V	3.2	254	A	3.0	262	A	3.7
247	A	1.0	255	I	3.5	263	A	2.0
248	A	1.5	256	I	4.7	264	A	.5

Code:
V = Visual
A = Auditory
I = Incomplete
NR = No response
NA = Not available
EE = Experimenter error
EM = Equipment malfunction

RAW DATA - SUBJECT 2

Trial No.	Response	Latency (in seconds)	Trial No.	Response	Latency (in seconds)	Trial No.	Response	Latency (in seconds)
---- Start Baseline ----			13	A	1.5	28	I	.7
---- Start Day 1 ----			14	I	1.5	29	I	.7
1	I	NA	15	V	1.0	30	V	.5
2	A	NA	16	I	1.2	31	I	.5
3	I	NA	17	I	1.0	32	I	.5
4	I	NA	18	V	1.0	33	I	.5
5	I	NA	19	V	.5	34	V	.4
6	V	NA	20	NR		35	V	.4
7	I	NA	21	V	.5	36	V	.6
8	I	NA	22	I	2.2	37	I	.4
9	I	NA	23	V	2.7	38	I	.4
10	I	NA	24	V	.3	39	I	2.0
11	I	NA	25	V	1.0	40	V	1.0
---- Start Day 2 ----			26	I	.7	41	I	.7
12	NR		27	I	.9	42	I	.9

Trial No.	Response	Latency (in seconds)	Trial No.	Response	Latency (in seconds)	Trial No.	Response	Latency (in seconds)
43	NR		59	I	4.5	74	I	8.0
44	V	NA	60	A	1.0	75	V	.5
---- Start Day 3 ----			61	EM		76	V	1.0
45	EM		62	EM		77	I	.9
46	I	.5	63	EM		78	I	.8
47	V	.6	64	I	1.2	79	I	1.2
48	V	.5	65	EM		80	V	.9
49	I	2.5	66	EM		81	A	1.4
50	V	1.0	67	I	1.5	82	I	1.4
51	I	1.0	68	I	1.2	83	I	.6
52	I	.9	---- Start Day 4 ----			84	A	2.2
53	I	.5	- Start Auditory Reinf.-			85	NR	
54	V	15.5	69	A	.5	86	I	.8
55	I	1.0	70	I	.5	87	A	3.4
56	V	.9	71	I	.6	88	A	2.4
57	EM		72	I	.4	89	I	NA
58	EM		73	I	.6	90	A	3.0

Trial No.	Response	Latency (in seconds)	Trial No.	Response	Latency (in seconds)	Trial No.	Response	Latency (in seconds)
91	I	1.6	107	A	3.4	124	I	4.2
92	I	8.7	108	I	2.4	125	V	2.4
93	NR		109	I	2.7	126	A	2.5
94	A	2.1	110	A	2.5	127	A	2.4
95	A	1.0	111	A	2.8	128	V	2.2
96	A	3.5	112	NR		129	NR	
97	A	3.5	113	A	2.4	130	V	2.3
98	A	3.0	114	NR		131	A	2.5
99	A	3.2	115	A	4.4	132	A	2.9
100	I	5.0	116	A	3.4	133	A	3.5
101	NR		117	A	2.3	134	I	1.4
102	A	2.8	118	NR		135	NR	
103	A	2.3	119	A	4.4	136	I	6.0
104	A	2.4	120	A	3.0	137	EE	
105	A	2.4	121	V	2.6	138	I	2.5
106	A	2.2	122	A	2.2	139	I	7.8
-- Start Visual Reinf. --			123	EE		140	V	2.8

Trial No.	Response	Latency (in seconds)	Trial No.	Response	Latency (in seconds)	Trial No.	Response	Latency (in seconds)
141	NR		157	I	6.5	174	I	5.0
---- Start Day 5 ----			158	V	4.5	175	A	2.5
142	A	5.0	159	A	2.5	176	I	1.4
143	A	2.6	160	A	3.0	177	A	4.6
144	I	7.5	161	A	1.2	178	A	NA
145	I	3.5	162	A	2.2	179	A	5.4
146	I	6.5	163	I	9.6	180	I	4.5
147	I	6.5	164	A	5.5	181	EM	
148	V	4.1	165	A	2.7	182	V	2.6
149	A	3.4	166	A	3.2	183	I	5.0
150	A	3.3	167	A	4.0	184	A	7.0
151	A	4.7	168	I	7.2	185	A	3.5
152	EM		169	A	5.5	186	A	10.1
153	A	4.5	170	I	3.0	187	A	2.0
154	A	4.2	171	A	3.3	188	A	4.0
155	I	1.7	172	A	3.1	189	I	4.5
156	A	5.3	173	A	4.0	190	A	3.0

Trial No.	Response	Latency (in seconds)	Trial No.	Response	Latency (in seconds)	Trial No.	Response	Latency (in seconds)
191	I	3.0	208	A	4.7	225	A	5.5
192	V	3.0	209	A	3.2	226	A	2.5
193	A	4.2	210	A	3.5	---- Start Day 6 ----		
194	I	3.7	211	I	5.5	227	A	3.5
195	I	7.0	212	I	8.0	228	V	2.2
196	I	5.4	213	V,A	2.8	229	V	2.6
197	I	7.7	214	I	9.0	230	A	6.5
198	I	3.2	215	A	3.0	231	V	6.0
199	NR		216	V	2.5	232	V	3.5
200	I	3.8	217	A	4.0	233	V	3.5
201	A	2.5	218	V	4.2	234	V	1.7
202	A	3.7	219	NR		235	V	4.6
203	V	4.0	220	I	11.0	236	V	2.8
204	V,A	2.5	221	V	4.2	237	V	4.5
205	I	9.0	222	NR		238	V	11.0
206	I	4.4	223	A	5.0	239	NR	
207	I	10.0	224	A	4.1	240	V	3.2

Trial No.	Response	Latency (in seconds)	Trial No.	Response	Latency (in seconds)	Trial No.	Response	Latency (in seconds)
241	I	3.1	257	I	7.2	-- Start Visual Reinf. --		
242	V	6.0	258	V	3.0	274	A	4.0
243	V	6.1	259	V	3.0	275	A	3.5
244	V	4.1	260	A	10.0	276	V,A	3.0
- Start Auditory Reinf. -			261	I	5.5	277	A	2.1
245	V	3.7	262	V	3.4	278	V	5.1
246	V	1.8	263	A	5.6	279	V	3.7
247	I	NA	264	V	3.3	---- Start Day 7 ----		
248	V	4.2	265	A	4.1	280	A	6.0
249	V	3.7	266	V,A	4.5	281	V	5.3
250	A	3.4	267	A	3.0	282	I	10.5
251	V	2.2	268	A	5.1	283	A	3.5
252	I	6.6	269	A	2.5	284	V	3.5
253	V	3.0	270	A	2.8	285	V	4.1
254	I	3.7	271	A	4.6	286	V	1.8
255	I	3.2	272	A	3.0	287	V	2.5
256	V	4.1	273	A	5.5	288	NR	

Trial No.	Response	Latency (in seconds)	Trial No.	Response	Latency (in seconds)	Trial No.	Response	Latency (in seconds)
289	V	4.1	305	I	10.1	322	A	3.5
290	A	9.5	306	I	7.0	323	A	2.5
291	V	3.6	307	A	3.5	324	V	1.2
292	A	7.0	303	A	3.0	325	A	6.0
293	I	7.6	309	A,V	1.5	326	A	3.5
294	V	3.3	310	I	5.5	327	I	2.4
295	V	4.4	311	V	2.0	328	A	1.6
- Start Auditory Reinf. -			312	V,A	1.2	329	I	3.2
296	V	2.0	313	V	3.0	330	I	7.3
297	A	3.6	314	V,A	2.5	---- Start Day 8 ----		
298	NR		315	A	3.6	-- Start Baseline ---		
299	V	5.0	316	I	1.7	331	A	5.2
300	A	1.5	317	A	4.0	332	A	2.5
301	EE		318	I	4.0	333	I	10.5
302	I	5.1	319	V,A	1.5	334	NR	
303	A	7.0	320	A	4.0	335	I	4.0
304	A	4.0	321	A	2.5	336	I	3.0

Trial No.	Response	Latency (in seconds)	Trial No.	Response	Latency (in seconds)	Trial No.	Response	Latency (in seconds)
337	A	4.0	354	I	4.0	371	V	.9
338	V	3.0	355	A	4.5	372	I	.8
339	I	3.2	356	NR		373	I	2.2
340	EE		357	A	4.5	374	V	3.1
341	A	5.5	358	I	1.4	375	V	.9
342	V	3.5	359	I	1.5	376	V	1.0
343	I	6.5	360	V	1.4	377	I	1.0
344	A	4.5	361	NR		378	V	1.0
345	A	3.0	362	I	1.4	379	A	3.0
346	A	3.0	363	A	1.0	380	V	1.0
347	V	4.1	364	A	4.7	381	I	.8
348	A	2.5	365	EM		382	I	4.7
349	A	3.0	366	V	5.2	383	A	1.5
350	A	2.5	367	V	.9	384	V	.8
351	A	6.5	368	V	.9	385	I	1.1
352	A	2.5	369	V	1.5	386	A	.8
353	V	1.9	370	V	1.0	---- Start Day 9 ----		

Trial No.	Response	Latency (in seconds)	Trial No.	Response	Latency (in seconds)	Trial No.	Response	Latency (in seconds)
387	A	1.5	404	A	2.5	421	V	5.0
388	A	3.0	405	A	5.3	422	A,V	5.0
389	A	6.0	406	A	1.8	423	V	6.3
390	V	3.7	407	A	4.5	424	A	4.1
391	I	8.5	408	A	5.5	425	V	5.0
392	A	6.0	409	A	1.4	426	I	2.5
393	A	4.0	410	I	4.4	427	I	5.0
394	A	2.6	411	I	4.3	428	A	3.0
395	A	4.0	412	I	5.5	429	I	2.3
396	A	3.5	413	A	2.3	430	A	6.0
397	A	2.2	414	A	2.0	431	NR	
398	A	3.7	415	A	1.5	432	A	3.2
399	A	3.5	416	V	.9	433	A	7.2
400	A	1.0	417	A	3.3	434	V	2.6
401	A	2.5	418	A	2.5	435	A	3.6
402	A	2.1	419	A	5.4	436	A	1.7
403	A	2.5	420	V	4.6	437	I	1.5

Trial No.	Response	Latency (in seconds)	Trial No.	Response	Latency (in seconds)	Trial No.	Response	Latency (in seconds)
438	A	2.1	454	A	3.2	471	V	1.0
439	I	1.4	455	A	1.2	472	V	1.0
440	I	1.7	456	A	3.5	473	V	3.1
441	A	1.3	457	A	2.6	474	A	3.0
442	A	1.5	458	I	7.0	475	V	2.6
---- Start Day 10 ----			459	A	.5	476	I	1.2
443	A	3.5	460	V	3.0	477	V	2.6
444	A	2.2	461	A	2.0	478	V	1.0
445	NR		462	A	1.6	479	V	1.0
446	NR		463	I	1.0	480	V	1.6
447	I	9.5	464	A	6.0	481	V	3.6
448	I	3.7	465	I	2.0	482	V	2.6
449	V	3.3	466	A	6.3	483	A	4.0
450	V	4.0	467	I	.8	484	A	6.0
451	I	5.0	468	A	1.0	485	V	4.0
452	A	4.6	469	V	4.5	486	V	3.5
453	A	2.8	470	I	2.8	487	V	NA

Trial No.	Response	Latency (in seconds)	Trial No.	Response	Latency (in seconds)	Trial No.	Response	Latency (in seconds)
488	I	.5	492	V	3.2	496	V	.8
489	I	3.6	493	A	2.2	497	A	2.1
490	I	.5	494	A	9.6	498	A	5.0
491	A	2.4	495	I	.6			

Code:
- V = Visual
- A = Auditory
- I = Incomplete
- NR = No response
- NA = Not available
- EE = Experimenter error
- EM = Equipment malfunction

RELIABILITY OBSERVER RAW DATA

Subject 1

Trial No.	Response	Latency (in seconds)	Trial No.	Response	Latency (in seconds)	Trial No.	Response	Latency (in seconds)
---- Start Baseline ----			43	A	1.1	153	V	.8
29	V	1.0	44	A	2.0	154	A	.7
30	I	7.2	45	I	1.0	155	V	.9
31	I	4.0	46	I	4.3	156	I	.7
32	I	3.5	47	I	2.3	157	A	1.5
33	I	5.4	48	A	1.8	158	A	.5
34	A	.5	49	V	3.1	159	A	0
35	I	5.1	50	A	.5	160	I	3.7
36	A	3.6	51	A	.5	161	I	3.5
37	V	1.5	52	V	3.4	162	A	.1
38	A	0	53	A	1.0	163	A	1.1
39	I	1.0	54	I	9.0	164	A	1.0
-- Start Visual Reinf. --			55	I	7.5	165	A	0
40	I	1.3	56	A	2.8	166	I	1.8
41	A	.1	- Start Auditory Reinf. -			167	A	2.5
42	A	1.9	152	V	1.7	168	A	.1

Trial No.	Response	Latency (in seconds)	Trial No.	Response	Latency (in seconds)	Trial No.	Response	Latency (in seconds)
169	A	2.0	185	V	5.0	228	V	3.2
170	A	2.0	186	I	7.5	229	A	6.8
171	I	1.0	187	I	6.2	230	I	9.1
172	A	4.5	188	V	3.2	231	I	5.3
173	A	2.7	189	V	5.1	232	V	1.7
174	A	3.7	190	V	4.5	233	I	3.6
- Start Visual Reinf. -			191	V	5.5	234	V	2.5
175	I	4.5	192	V	3.4	235	V	2.5
176	I	7.5	193	I	4.0	236	V	2.6
177	V	4.2	194	I	3.3	237	V	3.0
178	A	5.5	195	V	4.0	238	V	2.2
179	I	7.9	196	V	3.5	--- Start Baseline ---		
180	V	3.3	197	V	4.0	239	I	3.0
181	I	9.1	198	V	3.0	240	I	3.5
182	V	3.2	*			241	I	2.0
183	V	4.4	- Start Visual Reinf. --			242	A	2.8
184	I	13.5	227	V	2.9	243	A	3.2

Trial No.	Response	Latency (in seconds)	Trial No.	Response	Latency (in seconds)	Trial No.	Response	Latency (in seconds)
244	V	3.6	248	A	1.9	252	A	2.9
245	A	2.0	249	I	5.0	253	V	2.5
246	V	2.5	250	A	1.1	254	A	3.4
247	I	1.9	251	V	3.5			

*Auditory data for Subject 1 was not recorded thus it was not available for reliability checks.

RELIABILITY OBSERVER RAW DATA

Subject 2

Trial No.	Response	Latency (in seconds)	Trial No.	Response	Latency (in seconds)	Trial No.	Response	Latency (in seconds)
--- Start Baseline ---			27	I	.9	93	I	5.1
12	I	4.3	28	I	.5	94	A	1.5
13	A	1.8	29	I	.5	95	A	.2
14	I	1.2	30	V	.5	96	A	3.1
15	V	1.1	31	I	.3	97	A	3.4
16	I	1.1	32	I	.2	98	A	2.5
17	I	.8	33	I	.2	99	A	3.2
18	V	.6	34	I	.2	100	I	4.5
19	V	.5	35	V	.4	101	I	8.6
20	EE		36	V	.5	102	A	2.9
21	V	.4	37	I	.5	103	A	2.5
22	I	3.0	38	I	.5	104	A	2.1
23	V	2.5	-- Start Auditory Reinf.			105	A	2.0
24	V	.5	90	A	3.5	106	A	2.0
25	V	.8	91	I	2.0	- Start Visual Reinf.-		
26	I	.5	92	I	2.6	107	A	3.8

Trial No.	Response	Latency (in seconds)	Trial No.	Response	Latency (in seconds)	Trial No.	Response	Latency (in seconds)
108	I	2.0	250	A	2.7	268	A	5.0
109	I	2.5	251	V	2.5	269	A	2.6
110	A	2.5	252	I	6.7	270	A	2.8
111	A	4.0	253	V	3.2	271	A	4.2
112	I	6.1	254	V	3.8	272	A	3.1
113	A	2.4	255	I	2.8	273	A	5.0
114	I	5.0	256	V	3.8	-- Start Visual Reinf.--		
115	A	4.0	257	I	7.0	274	A	3.6
116	A	3.5	258	V	3.0	275	A	3.5
117	A	5.5	259	V	2.7	276	V	2.6
118	I	7.5	260	A	7.7	277	A	2.2
119	I	4.0	261	I	5.7	278	V	5.2
120	I	3.0	262	V	3.2	279	V	3.8
121	V	2.5	263	A	5.6	280	A	6.4
122	A	2.4	264	V	3.0	281	V	5.3
- Start Auditory Reinf. -			265	A	4.1	282	I	10.8
248	V	4.0	266	V	4.5	283	A	3.5
249	V	3.6	267	A	2.7	284	V	4.0

Trial No.	Response	Latency (in seconds)	Trial No.	Response	Latency (in seconds)	Trial No.	Response	Latency (in seconds)
285	V	4.2	301	EM		333	I	10.5
286	V	1.6	302	I	5.4	334	NR	
287	V	2.7	303	A	6.5	335	I	4.2
288	I	9.5	304	A	4.2	336	I	2.9
289	V	4.4	305	I	10.0	337	A	4.4
290	A	9.4	306	I	6.9	338	V	3.0
291	V	4.1	307	A	3.2	339	I	3.2
292	A	6.9	308	A	3.2	340	EM	
293	I	7.8	309	V	1.5	341	A	5.5
294	V	3.7	310	I	5.3	342	V	3.5
295	V	4.0	311	V	2.0	343	I	6.9
- Start Auditory Reinf. -			312	A/V	.3	344	A	4.6
296	V	2.0	313	V	3.6	345	A	3.1
297	A	3.9	314	A/V	2.7	346	A	2.9
298	NR		-- Start Baseline --			347	V	4.0
299	V	5.0	331	A	5.2	348	A	2.2
300	A	1.6	332	A	3.0	349	A	3.2
						350	A	2.8

APPENDIX F

VERBATIM DIRECTIONS FOR SUBJECTS

Bisensory Digit Span Task

Familiarization Trials

Today we're going to do some things to see how you remember. I'm going to let you see a group of numbers and hear a different group at the same time. Here, I'll show you. (Experimenter runs one trial.) That was called a trial and we will do ten more. I want you to try to remember as many of the numbers that you see and hear as you can. I will ask you at the end of the trial to tell me all you remember. Now, we will do the trials, but I will tell you before each trial what group of numbers to tell me first when it comes time to answer. For example, I will say,"(child's name), tell me the numbers that you saw first." Sometimes I will say, "tell me the numbers that you heard first." Remember to tell me as many numbers as you can, but always tell me the group I asked for first. Then you can tell me any other numbers that you can remember. Let's begin.

Criterion Trials

Now, we will do some more trials, but this time I'm not going to tell you which group to say first. At the end of the trial, tell me as many numbers as you can remember in any order you want.

Missing Units Task

Now we are going to do another memory task. I'm going to show you some words on the screen and you will also hear some words at the same time. It will be like this. (Experimenter runs one missing units trial). When the trial is over, I will show you, on this sheet (experimenter places stimulus sheet in front of the child), two of the words you have just seen and two of the words you have just heard. One of the words from the group you saw and one of the words from the group you heard will be missing. So you have to try very hard to tell me the missing words. Try to remember both, if you can. Let's begin.

APPENDIX G

RECORD SHEETS

MISSING UNITS RECORD SHEET

TRIALS 1-28

	V	A
Trial 1	jib	dim
2	bet	rib
3	bid	fop
4	cud	gap
5	box	lap
6	tug	fob
7	cob	dog
8	ham	put
9	bus	gag
10	gat	sin
11	bed	cut
12	lid	sad
13	bog	pig
14	rob	pip
15	bad	hop
16	pet	pit
17	mot	kid
18	pen	hip
19	sup	sag
20	way	pap
21	hat	hap
22	dub	gut
23	jut	set
24	jig	hid
25	pod	cot
26	hit	tab
27	wag	lax
28	yet	day

MISSING UNITS RECORD SHEET

TRIALS 29-56

	V	A
Trial 29	CAD	FIG
30	CAR	HAP
31	BEG	BUT
32	CUD	FAN
33	PEG	DIP
34	NEW	MOP
35	BUG	DOT
36	LOT	KEG
37	FED	BAT
38	MIX	FOG
39	JUG	PUG
40	LEX	SOT
41	SAP	FIT
42	MAT	MOD
43	FAD	GIN
44	RUG	WIG
45	LIP	FIX
46	BED	JOB
47	BAS	NOB
48	LOG	POT
49	RUT	MUM
50	HAD	PIN
51	MUG	PEW
52	HEN	HOG
53	DAB	HIM
54	ROT	RIM
55	MEN	JET
56	TOT	TAP

DIGIT SPAN RECORD SHEET

Name ______________________________ Age ____________

Date ____________________ School ______________________

	A	V
1.	2789	4035
2.	4267	1859
3.	1354	0672
4.	2604	1738
5.	7369	4218
6.	9034	2681
7.	6349	1052
8.	2753	4198
9.	1382	9705
10.	5927	8064
11.	5306	1472
12.	6398	2174
13.	2496	0351
14.	8513	2076
15.	0231	6485

_____ 1. ____________________

_____ 2. ____________________

_____ 3. ____________________

_____ 4. ____________________

_____ 5. ____________________

_____ 1. ____________________

_____ 2. ____________________

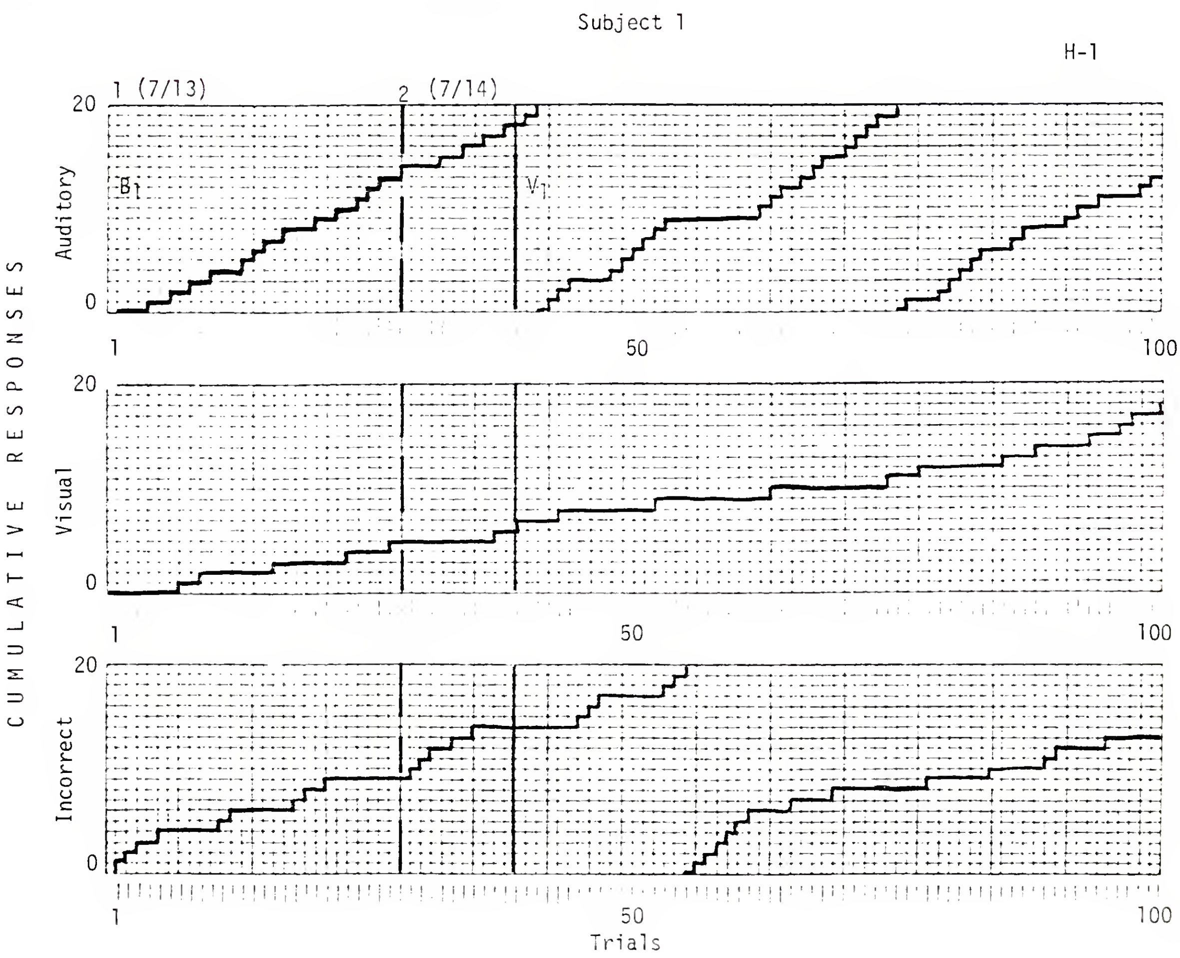
_____ 3. ____________________

_____ 4. ____________________

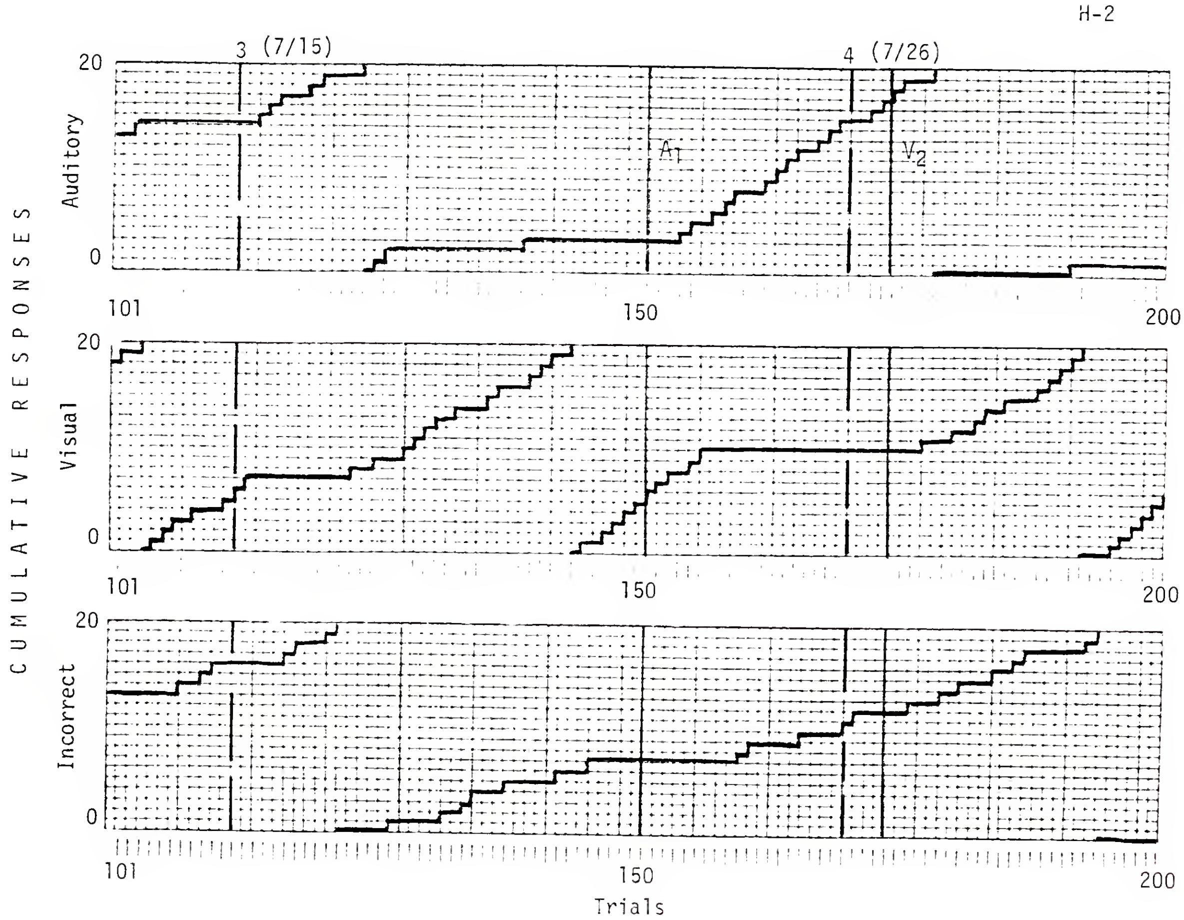
_____ 5. ____________________

APPENDIX H

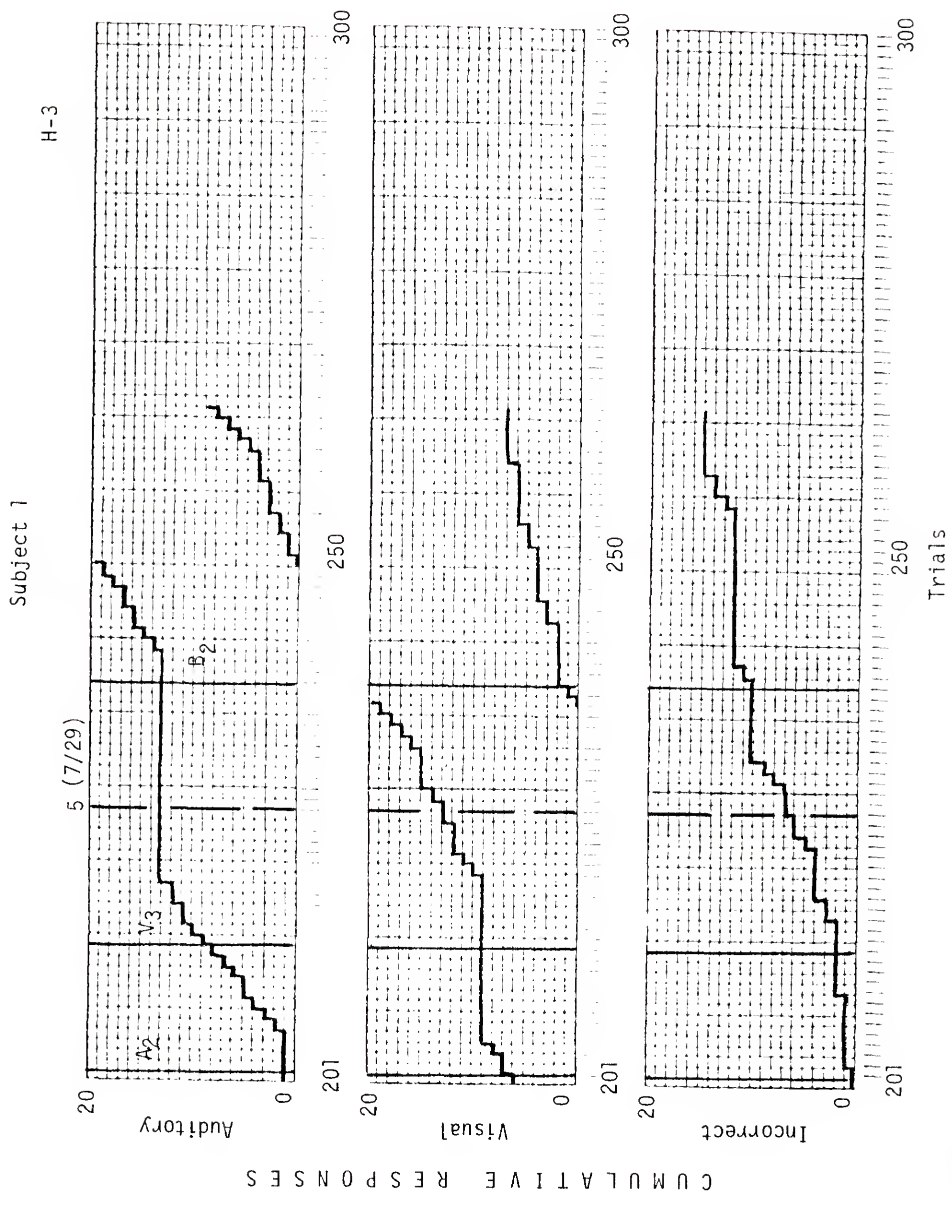
CUMULATIVE GRAPHS

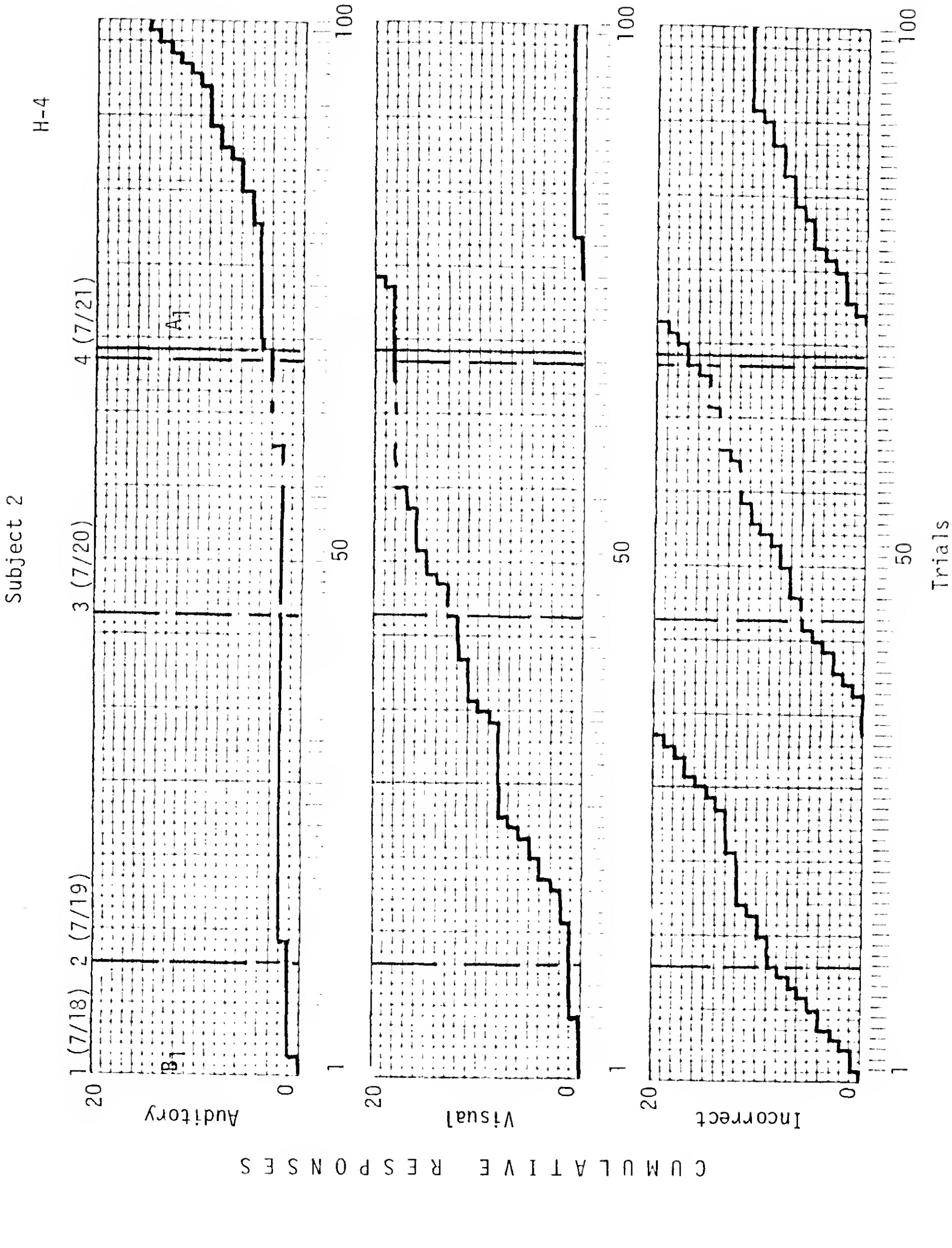

Subject 1
H-1
1 (7/13)
2 (7/14)
B1
V1
CUMULATIVE RESPONSES
Auditory
Visual
Incorrect
20
0
1
50
100
Trials

Subject 1



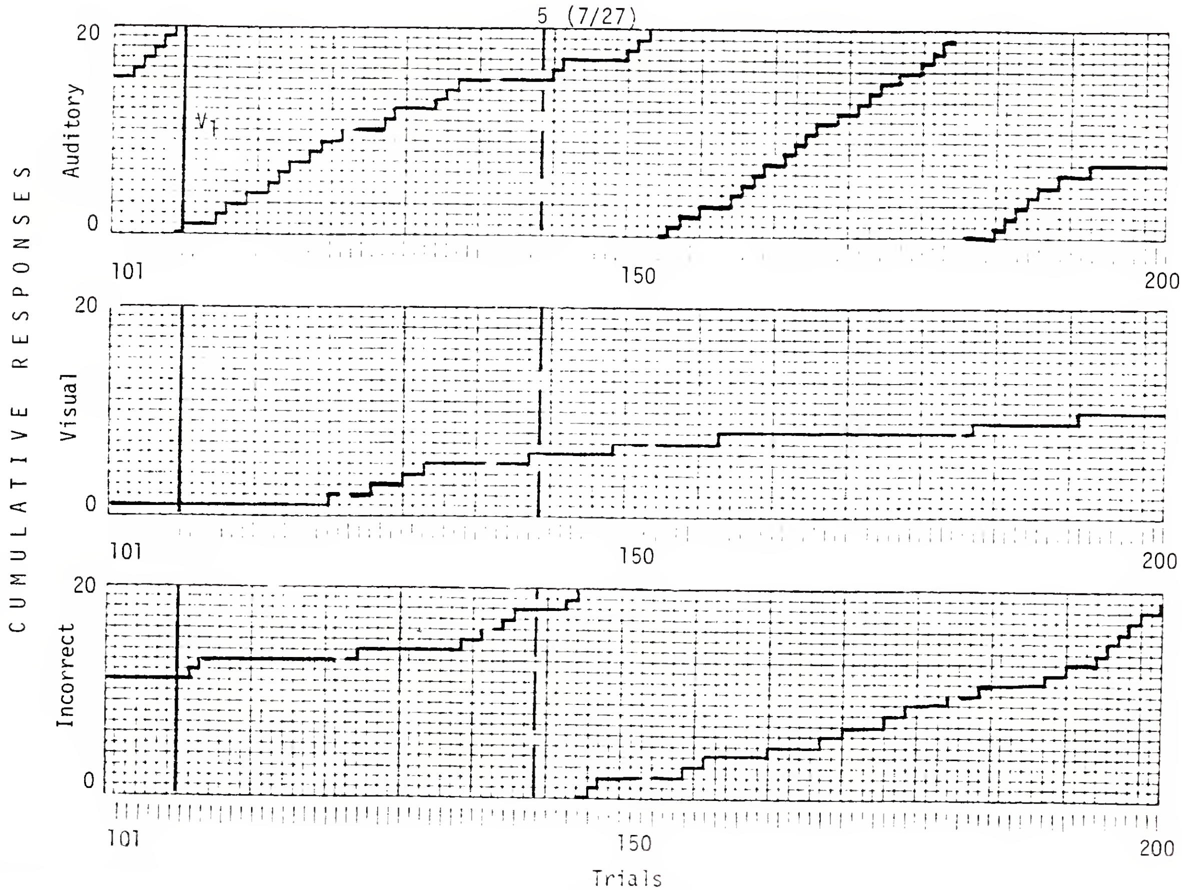
H-2
3 (7/15)
4 (7/26)
CUMULATIVE RESPONSES
Auditory
Visual
Incorrect
20
0
A_1
V_2
101
150
200
Trials

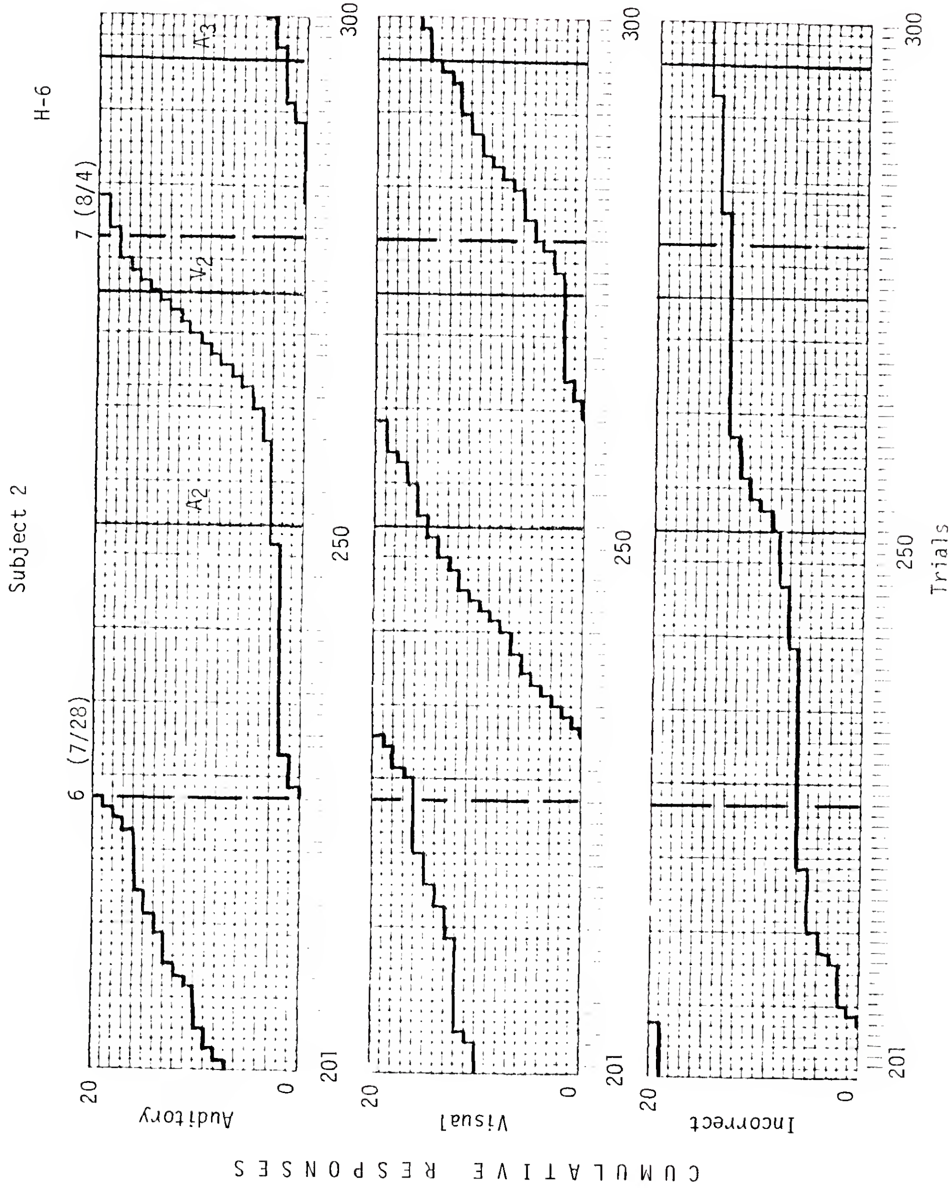

Subject 1
H-3
5 (7/29)
A_2
V_3
B_2
20
0
201
250
300
Auditory
Visual
Incorrect
Trials
C U M U L A T I V E R E S P O N S E S


Subject 2
H-4
1 (7/18)
2 (7/19)
3 (7/20)
4 (7/21)
A_1
B_1
Auditory
Visual
Incorrect
20
0
1
50
100
Trials
CUMULATIVE RESPONSES

Subject 2

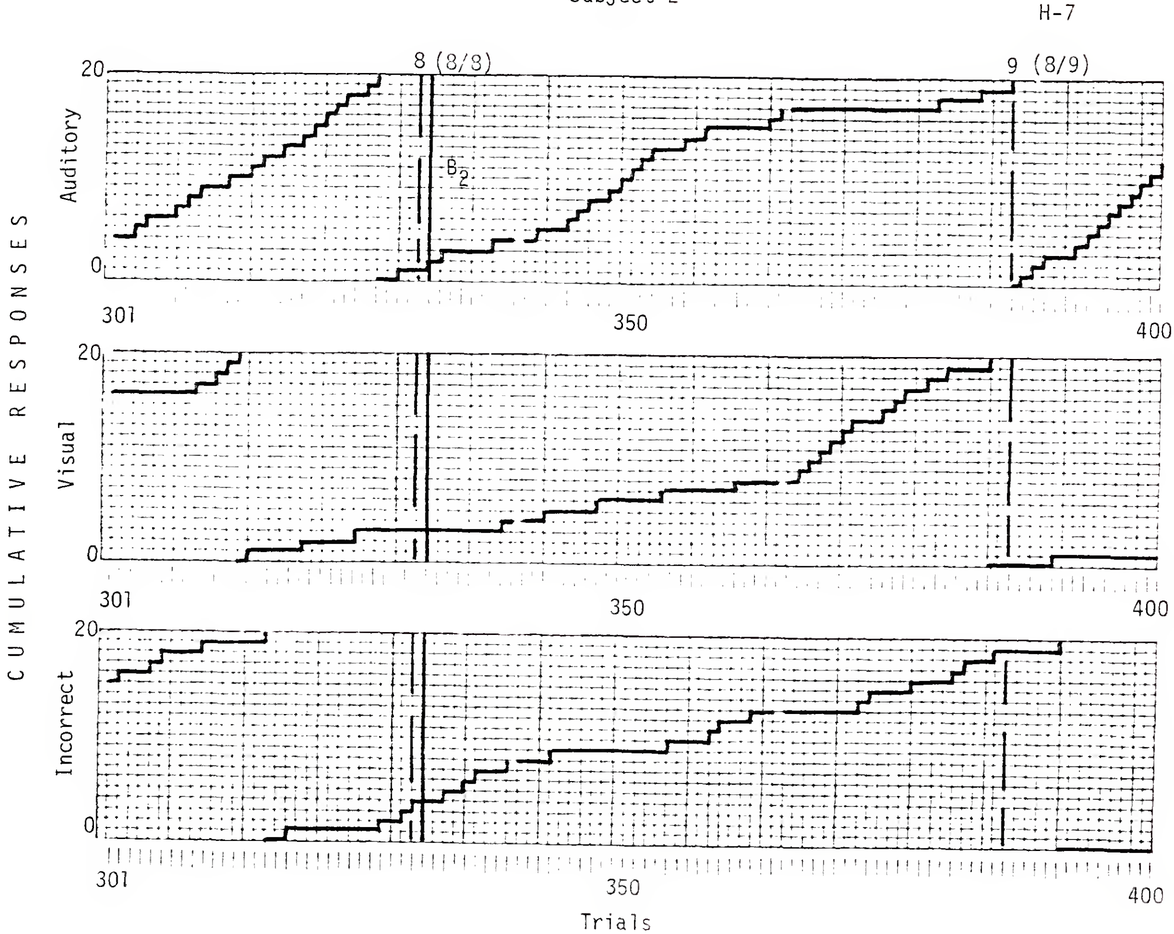
H-5

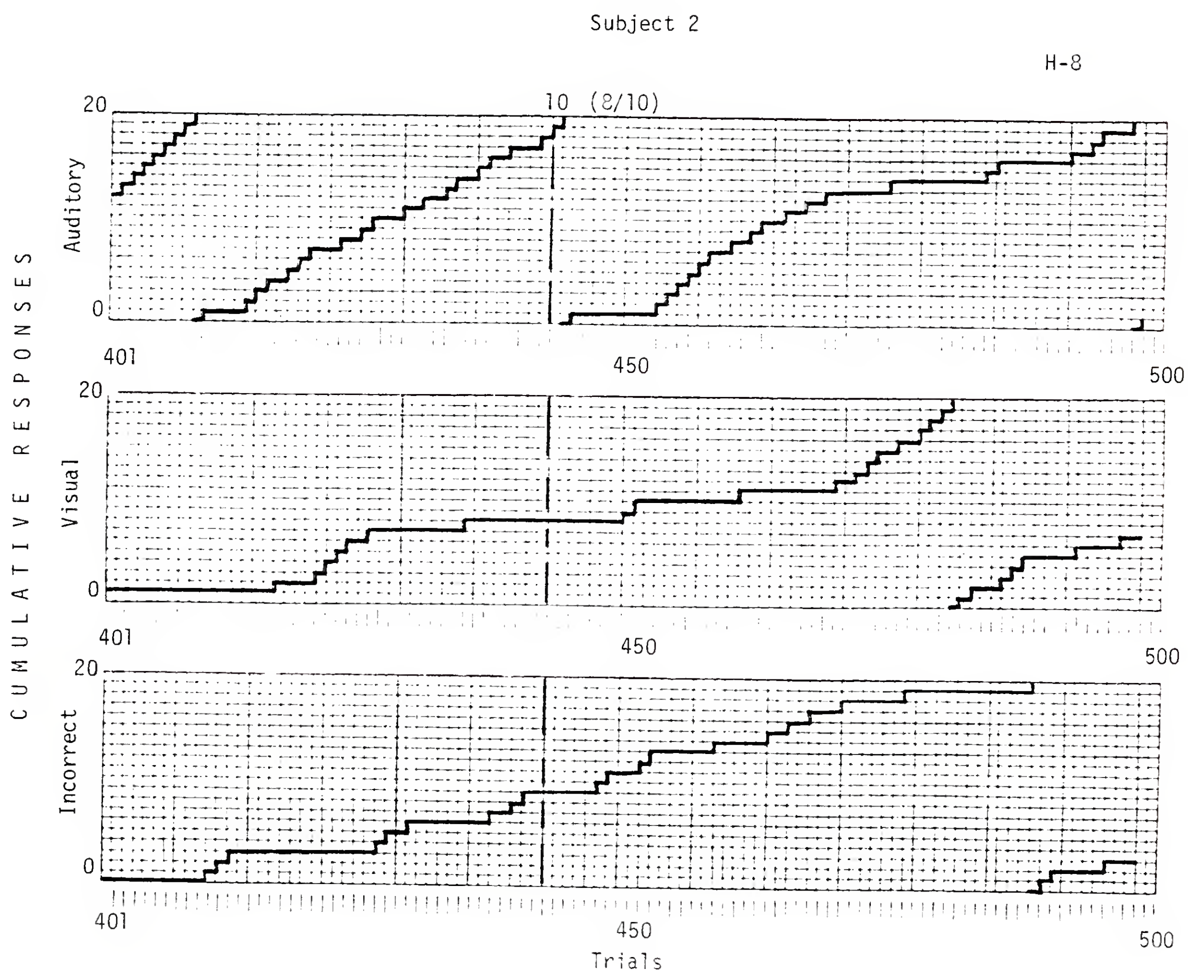

5 (7/27)
20
0
Auditory
V_1
101
150
200
Visual
Incorrect
CUMULATIVE RESPONSES
Trials



Subject 2
H-6
6 (7/28)
7 (8/4)
A2
V2
A3
20
0
Auditory
Visual
Incorrect
201
250
300
Trials
CUMULATIVE RESPONSES

Subject 2

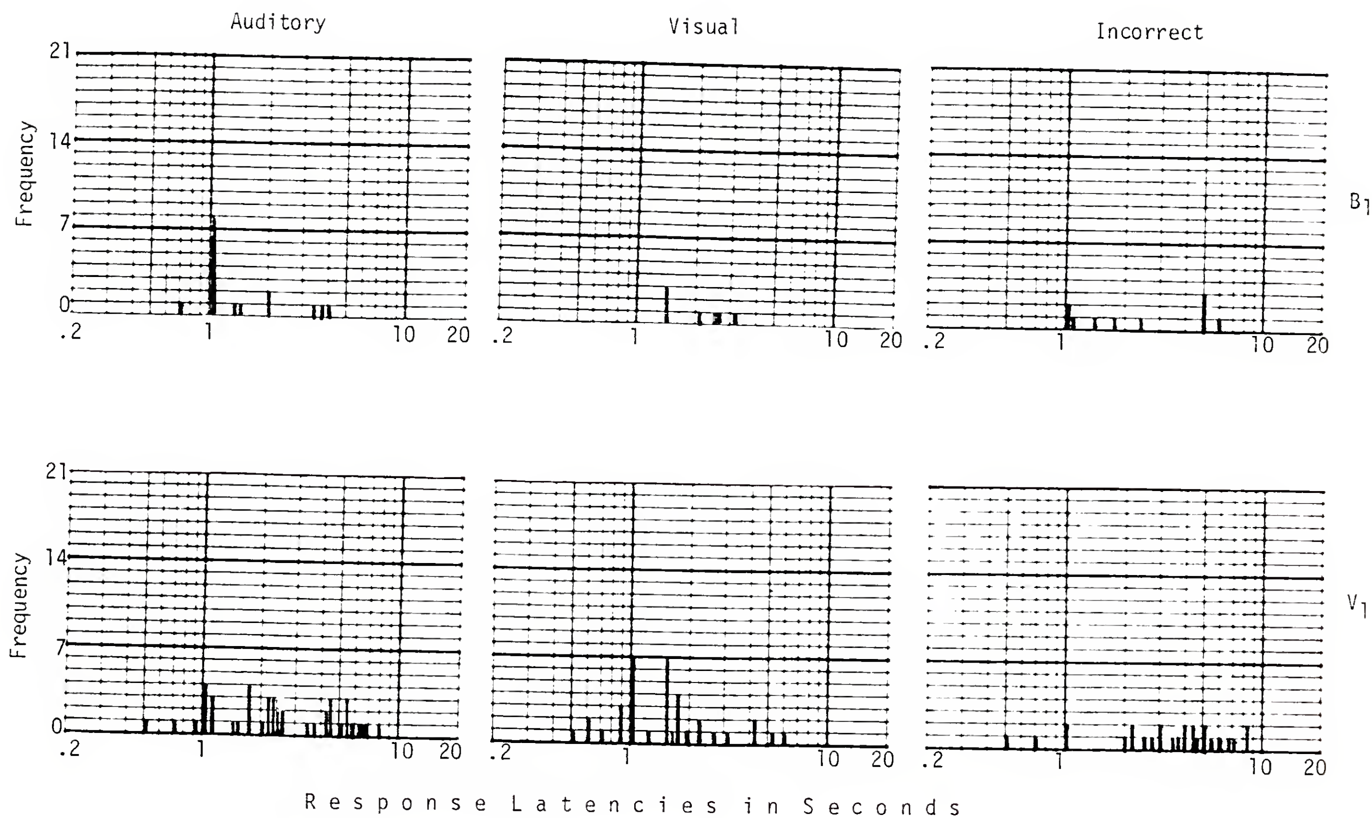

H-7
8 (8/8)
9 (8/9)
B2
CUMULATIVE RESPONSES
Auditory
Visual
Incorrect
20
0
301
350
400
Trials


Subject 2
H-8
10 (8/10)
CUMULATIVE RESPONSES
Auditory
Visual
Incorrect
20
0
401
450
500
Trials

APPENDIX I

GRAPHIC DISPLAYS OF RESPONSE LATENCIES

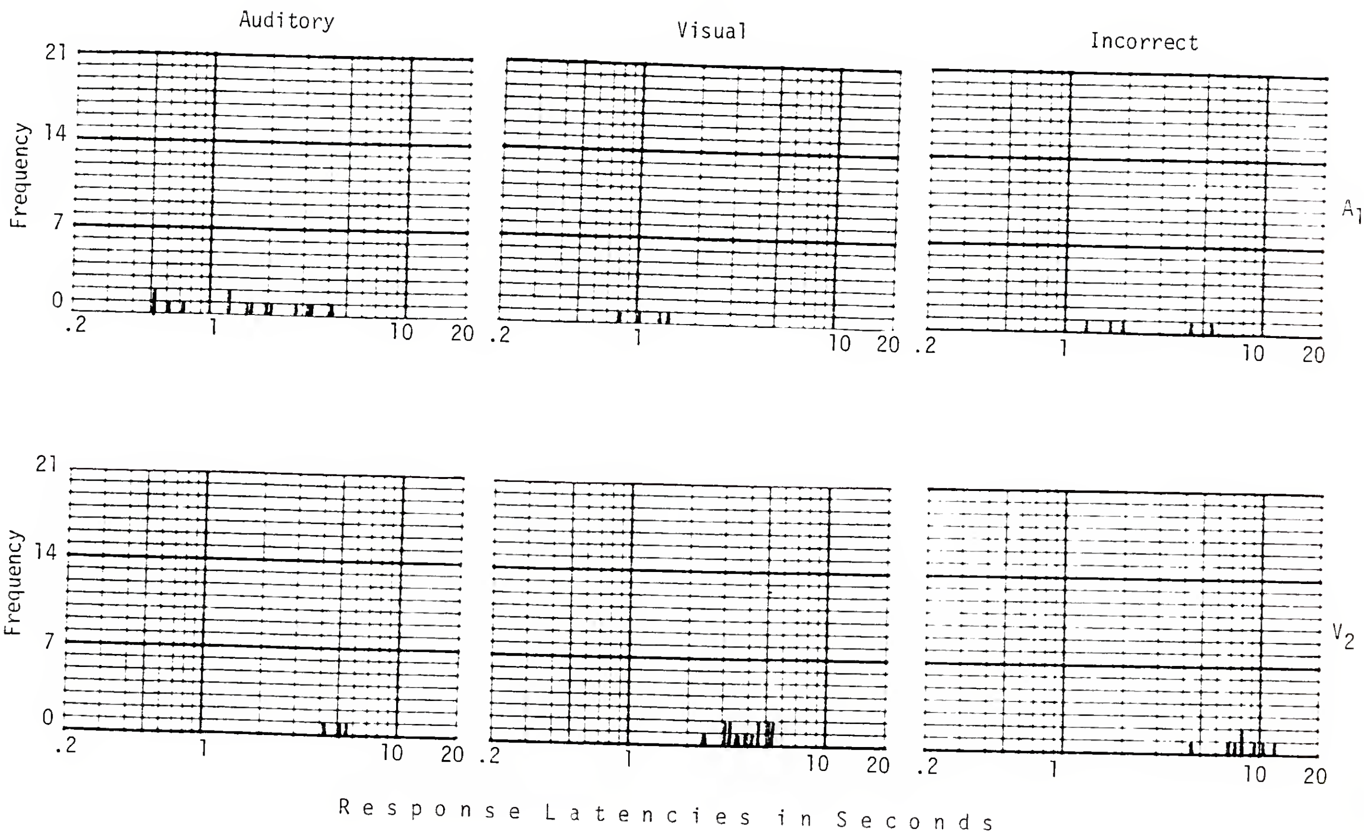
Subject 1
I-1



Auditory
Visual
Incorrect
Frequency
21
14
7
0
.2
1
10
20
B1
V1
Response Latencies in Seconds

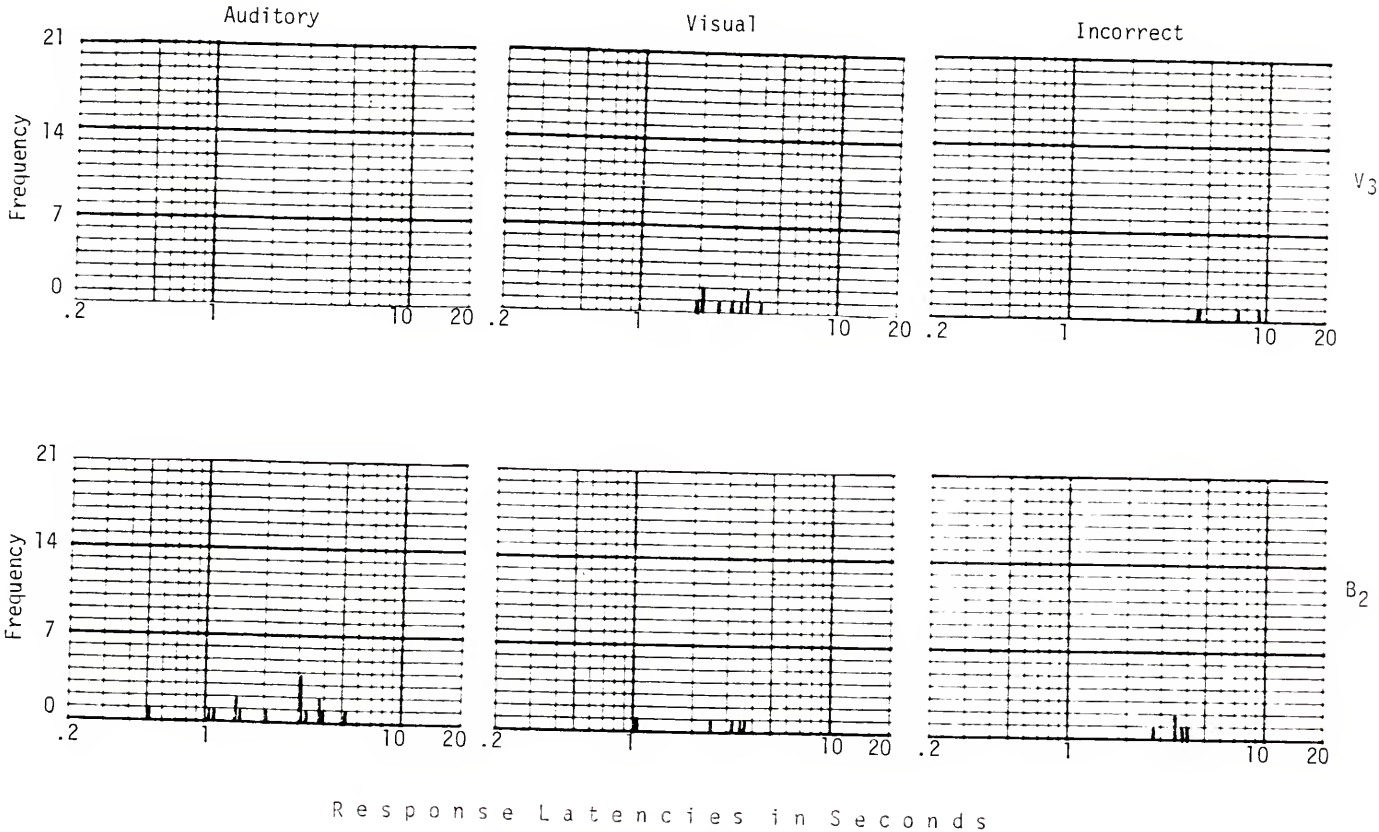
Subject 1

I-2


Auditory
Visual
Incorrect
Frequency
21
14
7
0
.2
1
10
20
A_1
V_2
Response Latencies in Seconds

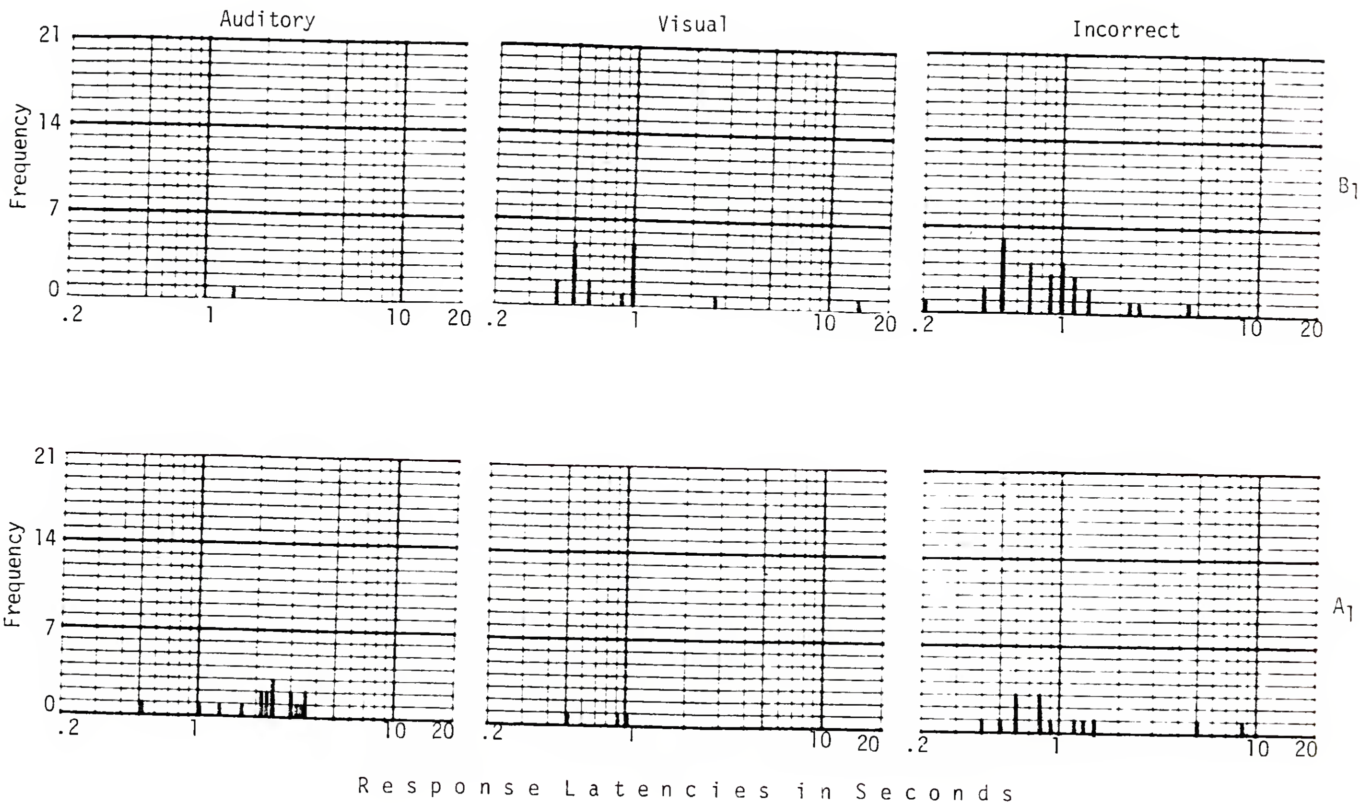
Subject 1

I-3


Auditory
Visual
Incorrect
Frequency
21
14
7
0
.2
1
10
20
V3
B2
Response Latencies in Seconds

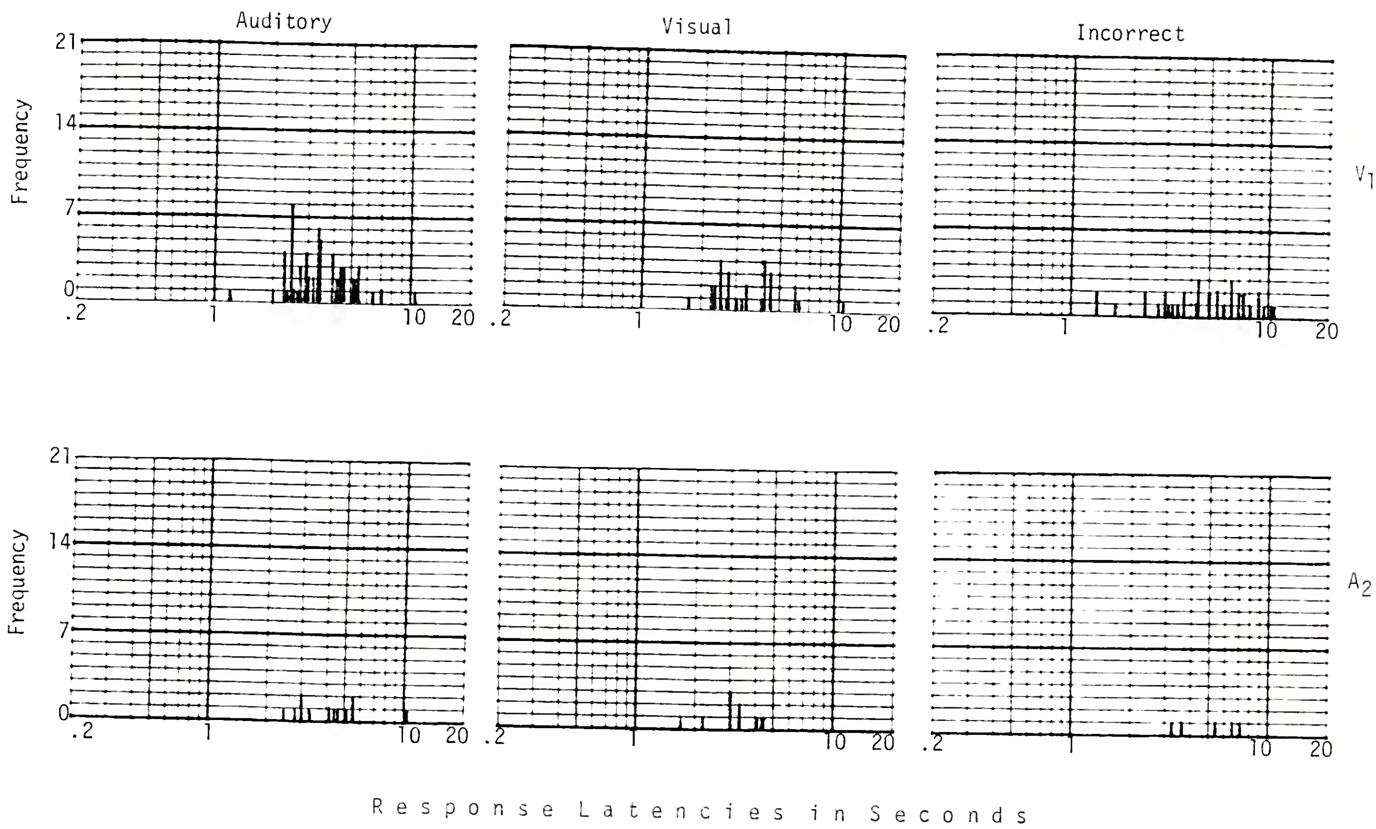
Subject 2

I-4


Auditory
Visual
Incorrect
Frequency
21
14
7
0
.2
1
10
20
B1
A1
Response Latencies in Seconds

Subject 2

I-5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Visual
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A2
Frequency
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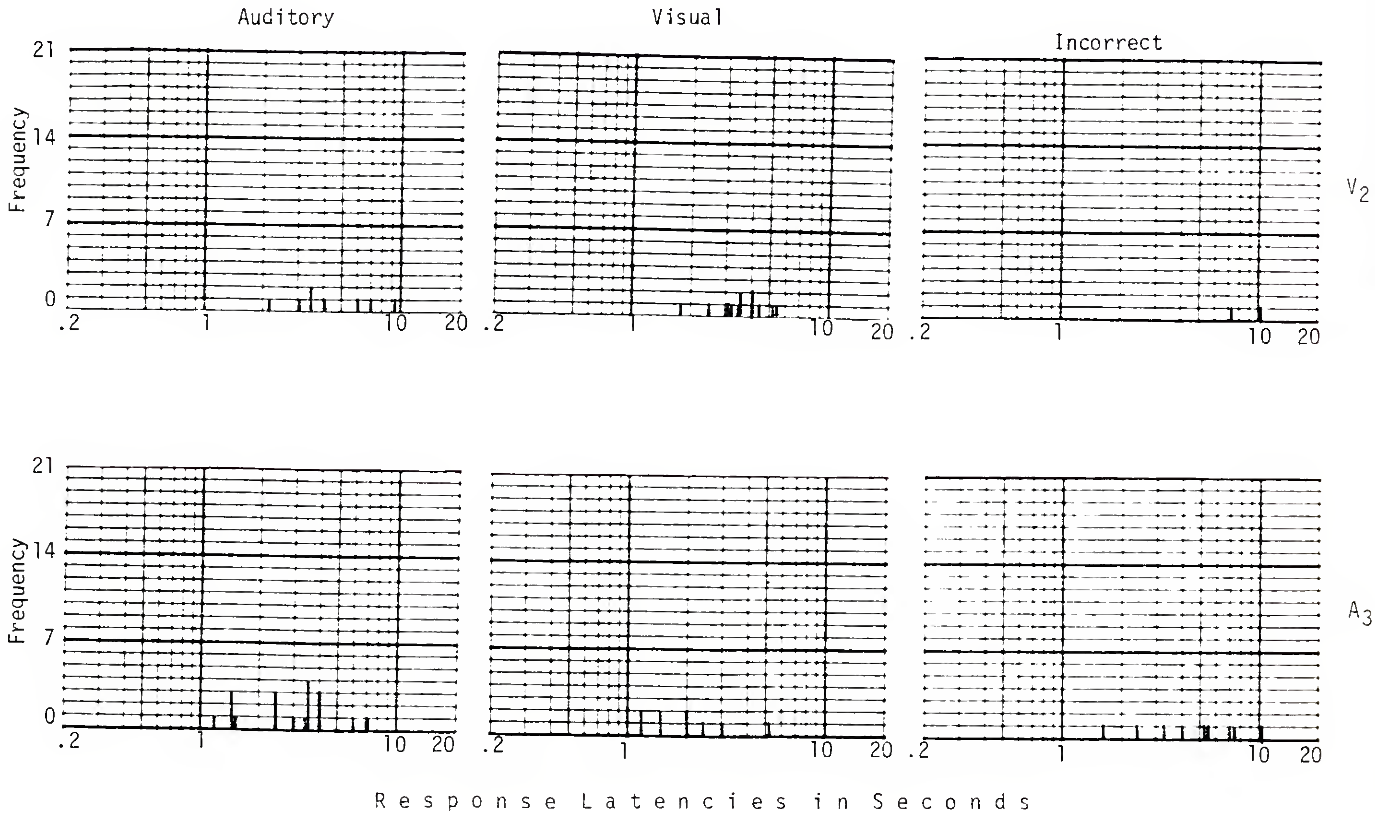
10
20
Response Latencies in Seconds

Subject 2

I-6



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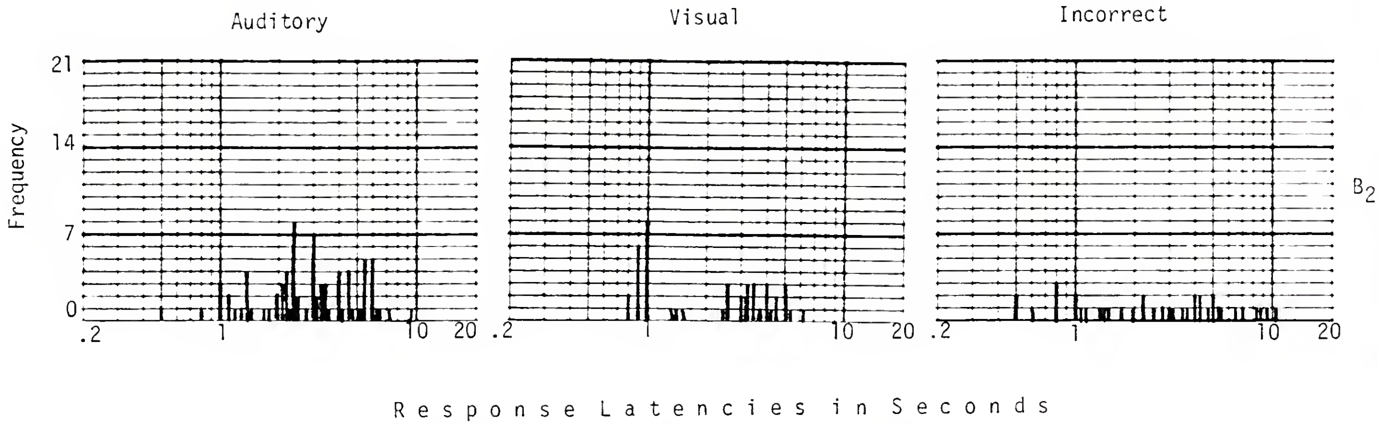
V_2
A_3
Response Latencies in Seconds

Subject 2

I-7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Frequency
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Response Latencies in Seconds

BIOGRAPHICAL SKETCH

Mark Alan Koorland was born at Cincinnati, Ohio, on March 22, 1947. When he was 15, he and his family moved to St. Petersburg, Florida.

He was graduated from Boca Ciega High School in 1965 and St. Petersburg Junior College in 1967. After graduating in special education from the University of Florida in 1970, he taught middle school educable mentally retarded children in Marion County, Florida. In 1972, upon completion of a Master of Education degree in special education with an emphasis in emotional disturbance, he worked as a consultant in the area of paraprofessional training for an NIMH drug abuse project operated at the University of Florida. In the Fall of 1972, he returned to the Marion County School system and took a position as a diagnostic-prescriptologist. The next year he taught in a resource room for emotionally disturbed elementary school children in Alachua County, Florida.

Mr. Koorland entered the doctoral program in special education in the area of learning disabilities at the University of Florida in 1974. At the same time he took a position as an instructor with the Career Associate in Special Education (CASE) program at Santa Fe Community College.

In 1975, Mr. Koorland held a summer appointment in special education at the University of South Alabama in Mobile. He returned to Santa Fe Community College in the fall and also resumed his doctoral studies. In 1976, he became coordinator of the CASE program.

Mr. Koorland will complete the requirements for the degree of Doctor of Philosophy in December, 1977. He has accepted a position as assistant professor of special education in the Department of Psychoeducational Services at Florida International University in Miami, Florida.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

William D. Wolking, Chairperson
Professor of Special Education

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Charles Forgnone
Professor of Special Education

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Cecil D. Mercer
Associate Professor of Special Education

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Henry S. Pennypacker
Professor of Psychology